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NOTICE TO AUTHORS OF PAPERS

1. Forwarding Address. Papers intended for publication in THIS JOURNAL should be submitted to Neil E. Gordon, Editor, The Johns Hopkins University, Baltimore, Maryland.

2. Manuscript. The manuscript submitted should be an original (not a carbon) copy, and typewritten, double-spaced, with 2–3 cm. margins. The title of the article should be followed by the name and address of the author. If the paper has been presented at a meeting, a footnote giving name of society, date, and occasion should immediately follow the author's name. The usual editorial customs, as exemplified in the most recent issues of the JOURNAL, should be followed as closely as possible.

3. References and Footnotes. Each reference to the literature and each footnote should be inserted without a number, as a separate line (or lines) immediately following the word to which it refers in the text. A reference to literature should include, in the order named, the title of book or article, author's name, edition or volume, pages, date of publication, and, in the case of books, publisher's name.

4. Illustrations. Not all articles lend themselves to illustrations, but articles which do should be accompanied by as many pertinent illustrations as possible. As a rule, apparatus, particularly if complicated, is best presented by means of line or working drawings. Photographs are sometimes sufficient, however. When both can be obtained, it is generally desirable to include both.

Photographs should have a gloss finish and should be at least post-card size—larger, if possible. Only prints which are unblurred and which show sharp contrast between light and dark areas can be satisfactorily reproduced.

Line drawings should be carefully prepared on plain white drawing paper or blue drawing cloth, twice or three times the size desired in the printed cut; it is convenient, when permitted by the scale required, to have them the size of the manuscript. When coördinate paper is used, it should be printed in blue only, with the important coördinate lines ruled over in black; the black square should in general not be less than ten millimeters on a side; the lines of the curves should be the heaviest, except the frame; points on the curves should be indicated by true circles, not crosses. The numbering of the coördinate axes, the number of the figure and any necessary explanations of the figure should be written in pencil in the margin of the sheet, as they are usually set up in type rather than reproduced from the drawing. All lines, numbers, and letters that are to be reproduced are to be so proportioned that they will be clearly legible in the cut.

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EDITOR'S OUTLOOK

Friedrich Wöhler

FRIEDRICH WÖHLER, like several other subsequently famous chemists, began his preparation for a scientific career as a student of medicine. After having studied at Marburg for some time he went to Heidelberg, where he was apparently greatly influenced by Gmelin who taught chemistry there at that time. He obtained his degree but never practised medicine.

Instead, he set about making arrangements to study chemistry under Berzelius, the most prominent chemist of that time. He tells how, upon his arrival at Stockholm, Berzelius himself opened the door to his knock and conducted him through the laboratory which had been the scene of so many famous discoveries. He marveled at the plainness of the quarters and the lack of facilities and equipment.

"The laboratory," as he related afterward, "consisted of two ordinary rooms furnished in the simplest possible way; there were no furnaces or draught places; neither gas nor water service. In one of the rooms were two common deal tables; on one of these worked Berzelius, the other was intended for me. On the walls were a few cupboards for the reagents; in the middle was a mercury trough, whilst the glass-blower's lamp stood on the hearth. In addition was a sink, with an earthenware cistern and tap, standing over a wooden tub, there the despotic Anna, the cook, had daily to clean the apparatus. In the other room were the balances, and some cupboards containing instruments; close by was a small workshop fitted with a lathe. In the neighbouring kitchen, in which Anna prepared the meals, was a small but seldom-used furnace and the never-cool sand-bath."

Berzelius judged that the young enthusiast needed training and experience in laboratory technic and he set him to making mineralogical analyses. When Wöhler worked hurriedly and with less care than Berzelius deemed desirable, the latter would remark, "Doktor, das war schnell aber schlecht."[1] Evidently these admonitions bore fruit, for Hofmann years later said of Wöhler that he was "calm and deliberate, entering upon a fresh problem after full reflection, guarding himself against each rash conclusion, and, only after the most rigorous testing, by which every chance of error seemed to be excluded, giving expression to his opinion."

Before Wöhler left Stockholm he had already begun the study of the cyanates which led to his meeting and life-long friendship with Liebig and to the classical synthesis of urea. That synthesis has largely

[1] "Doctor, that was quick but bad."

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overshadowed his other work, so that today there is no general appreciation of the breadth and extent of his contributions to chemistry. In all, Wöhler published nearly three hundred papers, and they dealt with practically every phase of chemistry known in his day. It is said that not a single element which had been discovered preceding or during his time was omitted from his studies.

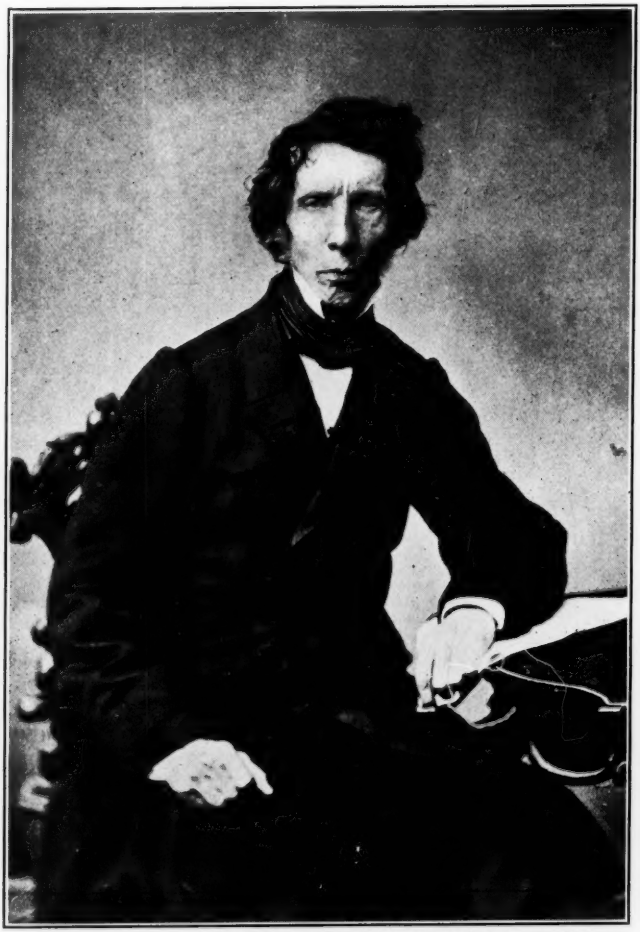
The joint investigation with Liebig of the benzoyl radical was as truly an epoch-making piece of research as the famous synthesis—in so far as chemistry itself is concerned. It had not, of course, such far-reaching philosophical implications. The preparation of metallic aluminum was another of Wöhler's achievements. The plaque reproduced on p. 1550 is appropriately cast in that metal.

Wöhler's personal habits were moderate and he was fond of outdoor exercise. These facts, coupled with a naturally vigorous constitution, enabled him to maintain a degree of activity which would have exhausted many a less fortunate man. Moreover, chemistry was to him an intensely interesting hobby—he never looked upon it as work. Liebig once wrote to him: "How happy art thou in thy work! Thou art like the man in the Indian fable who, when he laughed, dropped roses from his mouth."

But, with all his numerous projects and his absorbing interest in research, he also took pleasure in imparting knowledge. Some insight into his relationship with his students and their respect and affection for him is obtained in the reminiscences by Dr. Edgar Fahs Smith which appear on p. 1554, *et seq.* Surely here was that rare embodiment which the educator delights to contemplate as a universal possibility—the great teacher and the great investigator in one.

Fellowships Available

FOR SOME years past Dr. Wm. McPherson has compiled for the JOURNAL a list of fellowships in chemistry available at various institutions. No claim to absolute completeness is made. The Association of American Universities serves as a nucleus to which are added such data from other institutions as are readily available. Each year there have been some protests concerning omissions. Accordingly, we hereby serve notice that the customary compilation will appear in the January issue. Institutions which desire to be included are urged to forward complete information to the editorial office *immediately*.



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FRIEDRICH WÖHLER

CONTEMPORARY RECEPTION OF WÖHLER'S DISCOVERY OF THE SYNTHESIS OF UREA*

W. H. WARREN, CLARK UNIVERSITY, WORCESTER, MASSACHUSETTS

The story of Friedrich Wöhler and his synthesis of urea is familiar to every student of organic chemistry, for in their opening lectures teachers of this subject usually call particular attention to this discovery as the first instance of the artificial formation of a compound produced by the animal organism. Then, if the student in turn becomes a teacher, he yearly repeats the tale to each new class as it begins the study of perplexing formulas, mystifying transformations, and reactions without end.

This synthesis of urea, published one hundred years ago by Wöhler, when he was twenty-eight years of age, fully justifies the appearance of his name on the front pages of nearly every textbook of organic chemistry. Indeed this fact is of more than ordinary significance, otherwise we should not on this occasion be recalling the name of Wöhler to do him honor, nor should I have the privilege of telling you how his contemporaries received this synthesis which overthrew what most chemists had hitherto regarded as a well-established dogma, namely, that compounds produced by the plant or animal organism could not be formed by artificial means in the laboratory.

In order that we may have a clear idea of just what Wöhler put before his contemporaries, I will briefly summarize his paper of 1828,[1] a contribution of only four pages. He begins by referring to an earlier Swedish paper written in 1824[2] in which he does everything but call "the peculiar white crystalline substance" by the name of urea. In other words, it seems to me that 1824, and not 1828, should be taken as the date of Wöhler's synthesis of urea. Menschutkin[3] has expressed this opinion in a paper published in Russian in 1913 and, unaware of the existence of this paper, I recently called attention[4] to the same fact. Yet the paper of 1828 is usually the only one mentioned. In this Wöhler says that he has already shown that cyanogen and aqueous ammonia give, among other

* Read at the Seventy-Sixth Meeting of the American Chemical Society, Swampscott, Mass., September 11, 1928, in commemoration of the centenary of Wöhler's discovery of the synthesis of urea.

[1] F. Wöhler, "The Artificial Formation of Urea," *Pogg. Ann.*, **12,** 253 (1828).

[2] F. Wöhler, "Om några föreningar af Cyan," *Kongl. Vetens. Akad. Handl.*, **1824,** 328; the same translated into German: "Ueber Cyan-Verbindungen," *Pogg. Ann.*, **3,** 177 (1825).

[3] B. N. Menschutkin, "An Account of the First Organic Synthesis," *Annals* of the Polytechnic Institute of St. Petersburg, **20,** 289 (1913).

[4] W. H. Warren, "The Complete History of Friedrich Wöhler's First Organic Synthesis," *Ber. deut. chem. Ges.*, **61** (1928), *Abt. A*, 3; see also E. v. Lippmann, *Ber. deut. chem. Ges.*, **61** (1928), *Abt. A*, 58.

things, oxalic acid and a white, crystalline substance, which has proved to be identical in every respect with urea. This he calls a remarkable fact because it is an instance of the artificial production of an organic substance of animal origin from inorganic materials. Then he adds that the best way to prepare urea is by the action of ammonium chloride on silver cyanate, or ammonia on lead cyanate. In these few words I have stated the essential facts of the discovery as given by Wöhler.

In the latter part of this paper Wöhler observes that urea and ammonium cyanate give identical analytical results. Then he concludes by stating that the same thing has been observed in the case of cyanic and fulminic acids, as well as in that of ethylene and a liquid hydrocarbon, that is, Faraday's butylene. He does not omit to add, however, that he refrains from indulging in any speculations concerning bodies that give the same analytical results but possess different properties, since further experiments in many similar cases are necessary before general laws can be deduced. Wöhler is here referring to an entirely different matter, that is, to what was soon to be called *isomerism*. Cohen[5] says that Berzelius[6] seemed to be far more deeply impressed by the rare example of isomerism, furnished by the conversion of ammonium cyanate into urea, than by this much quoted synthesis. Other comments upon the synthesis of urea by Berzelius, which I shall mention elsewhere, seem to cast some doubt upon the correctness of such a view.

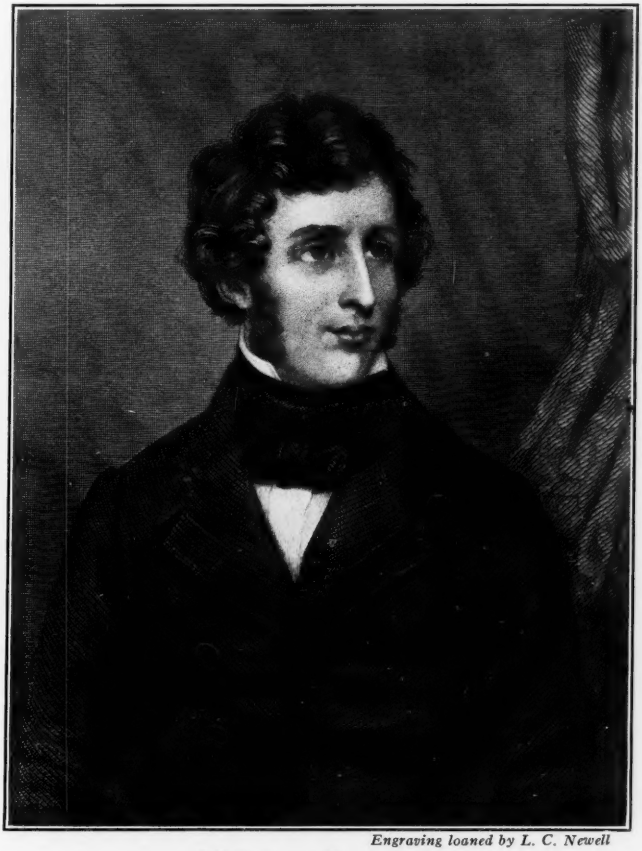
The shortness of this paper and the apparent simplicity of the experiment described may cause some of us to wonder why this synthesis has been considered so important. Like most great discoveries it was not the outcome of any preconceived plan. Wöhler was greatly surprised by it, for he had expected an entirely different result. Those wishing to detract from its importance may call the discovery accidental but they must explain why another chemist five years before, as I shall show, let the opportunity of making this discovery slip through his hands. The truth is that Wöhler was an unusually keen observer and he has presented us with a piece of very careful experimental work. Its importance perhaps is not to be gaged so much by the synthesis itself as by the promise it gave of a greatly broadened horizon for organic chemistry. Attention was directed to the possibility of synthesizing other organic compounds and this small beginning inaugurated that wonderful era of synthetic organic chemistry which is still in progress.

Let us now inquire how we should expect the chemists of that day to respond to a discovery as unexpected and revolutionary as that announced by Wöhler. In 1828 the chemical world was no more agreed upon all the subjects claiming attention than it is today. So it is reasonable to expect

[5] "Organic Chemistry for Advanced Students," **1910**, p. 9.

[6] *Jahresbericht*, **14**, 282 (1828).

that Wöhler's surprising announcement would have given rise to considerable discussion. Berzelius and his followers were firmly convinced that an impassable gulf lay between inorganic and organic compounds. The great Swedish chemist had emphatically declared that the latter never could be made in the laboratory, because they were dependent for their



Engraving loaned by L. C. Newell

WÖHLER AS A YOUNG MAN

existence upon the vital force of living organisms. Yet Wöhler, the favorite disciple of Berzelius, while experimenting in the great master's laboratory, accomplished the impossible and announced it four years later. Just what Berzelius had to say about this discovery will be told presently.

There were some chemists who were not convinced that the synthesis of urea had conclusively proved that vital force was not essential for the

production of organic compounds. Among the number seems to have been Wöhler himself, for in a letter[7] to Berzelius announcing his discovery he says: "I must tell you that I can make urea without the use of kidneys, or of any animal, either man or dog. Ammonium cyanate is urea." Then, as if doubting whether this formation of urea wholly disproved the idea of the absolute need of vital force, he adds:

> But can this artificial formation of urea be regarded as an example of the production of an organic substance from inorganic materials? It is a striking fact that in order to produce cyanic acid (and also ammonia) there must always originally be an organic substance, and a natural philosopher might say that the organic part had not disappeared either from the animal charcoal, or from the cyanogen compounds made from it, and consequently that it is always capable of giving rise to an organic body.

Yet those chemists, including Wöhler, who were more or less impressed by the importance of this objection, seem to have overlooked the fact that Scheele[8] had produced potassium cyanide in 1783 by heating ammonium chloride and potassium carbonate not only with carbon but also with graphite.

Not all the chemists of that day, however, were convinced of the absolute need of vital force for the production of organic compounds. Among the number was the famous French chemist, Chevreul. In his textbook[9] he says:

> There exist a large number of substances found only in animals, or plants, which can be produced by no chemical procedure known to us at the present time. But to regard this distinction as absolute and invariable would be contrary to the spirit of science. It would be to declare the uselessness of all attempts having as their object the formation of compounds identical, or analogous, to those today regarded as peculiar to organized beings.

Consequently, Chevreul regarded it as incorrect to suppose that life, or vital force, alone can produce compounds absolutely distinct from inorganic compounds. In the same year (1824) in which the second edition of Chevreul's book appeared, Wöhler artificially prepared oxalic acid and urea from cyanogen, and four years later announced the artificial formation of the latter from these materials. Chemists like Chevreul hailed this achievement of Wöhler with joy, for they realized that a new era had dawned. The meaning to them of the synthesis of urea was that other organic compounds could also be made in the laboratory and it was not long before their prediction came true.

The discovery made by Wöhler ought, it might seem, to have brought forth many expressions of opinion from his contemporaries. Yet it does

[7] O. Wallach, "Briefwechsel zwischen J. Berzelius und F. Wöhler," Leipzig, vol. 1, 208 (1901).

[8] C. Graebe, "History of Organic Chemistry," Berlin, vol. 1, 55 (1920).

[9] *Ibid.*, p. 34.

not appear to have done so. Little mention of the urea synthesis is to be found in the journals and these few references are often found where least expected. On the other hand, personal letters furnish much valuable information. Wöhler certainly received many congratulatory letters from his colleagues and others. If all these letters could be examined, they would probably be found to contain many items of interest. With few exceptions, however, they are not available. Yet, when the nature of Wöhler's achievement is taken into consideration, it is not difficult to understand why so little mention of it was made. He did not propose a new theory for his contemporaries to support or oppose. Wöhler was not a theorist but an intensely practical man. When he found that urea was produced instead of the expected ammonium cyanate, he had a fine chance to speculate about the existence of two bodies having the same composition but different properties. Yet he concluded his paper with the remark that he should refrain from indulging in speculations so naturally suggested by these facts. Strange as it may seem, it is probably true that Wöhler preferred practice to theory largely on account of the attitude of Berzelius, the originator and stubborn defender of the electrochemical theory. As evidence that Berzelius set practice above theory may be cited his displeasure when Liebig gave too free rein to what the great master regarded as extravagant theorizing.[10] But whatever be the explanation, certain it is that Wöhler was a finder of facts and not a weaver of theories. Having found a fact, he submitted it to every possible test before putting it into print. As a result, whatever he published was correct and not subject to revision. His synthesis of urea was a fact which could be verified by repeating his experiment. It admitted of no difference of opinion. Had a contemporary written a paper about Wöhler's discovery, it would of necessity have been a eulogy. Needless to say, such papers rarely, if ever, appear in chemical journals. This explains, I think, why so little is to be found in the literature about the synthesis of urea.

In our search for contemporary opinion, we naturally turn first to Wöhler's teachers to learn what their estimate of his achievement was. Under Leopold Gmelin and Berzelius, Wöhler received the best chemical instruction of his day. What these two teachers thought of their former pupil's synthesis of urea would be interesting. In his exhaustive textbook Gmelin says very little on the subject nor, so far as I am aware, does he refer to the matter in any of his scientific papers. Gmelin must have held Wöhler in high esteem, for the latter's scientific talents impressed him so favorably that he advised his pupil to give up medicine and devote himself to chemistry. Moreover, it was Gmelin's advice that decided Wöhler to go to Stockholm and study with Berzelius. Finally, when Wöhler returned

[10] Justus Carrière, "Berzelius and Liebig; Their Letters from 1831–1845," 2nd edition, Munich, **1898,** p. 249.

from Sweden, by the advice of Gmelin he was offered a *privat-docentship* at Heidelberg which he did not take. Whatever recognition Wöhler received from Gmelin—and it is hardly to be supposed that it was not forthcoming—must have come by letter, or possibly by word of mouth, two sources of information beyond our reach.

Berzelius, on the other hand, has left no doubt as to what he thought of the synthesis of urea. In his famous textbook[11] he says:

> Wöhler has made the very remarkable discovery that urea can be artificially formed by treating freshly precipitated silver cyanate with a solution of ammonium chloride. This silver salt is converted into silver chloride and urea is obtained instead of ammonium cyanate which should be formed. Urea is also formed when lead cyanate is treated with ammonium hydroxide.

He has also led some chemists to infer that he attached more importance to the example of isomerism offered by the urea synthesis than to the synthesis itself by making the following comments:

> This is a very remarkable transformation. We are here dealing with a substance having exactly the same composition as a salt. Yet it is no salt, for it is not decomposed by bases, acids, or salts, as it should be if it were a salt. On the contrary, it has all the properties of an organic compound atom of the first order and combines partly with acids and partly with bases. This is an example, therefore, that shows how compounds, containing the same relative number of atoms of the elements, can differ in their chemical properties, because of the different relation of the simple atoms to one another in a compound atom.

Berzelius gave prominence to the synthesis of urea not only in his textbook but he also referred to it in his *Jahresbericht*[12] in these words:

> Beyond all question one of the most unexpected and therefore most interesting discoveries in the field of animal chemistry is the artificial production of urea. This discovery was made by Wöhler who found that the treatment of silver cyanate with ammonium chloride solution, or of lead cyanate with ammonium hydroxide, led to the formation not of ammonium cyanate but of a crystalline substance which in all its properties differed in no wise from pure urea, and which therefore *is urea*.

The power of Berzelius' name and the wide circulation of his textbook and *Jahresbericht* leave no room for doubt that Wöhler's contemporaries held his scientific ability in high esteem.

In 1823 Wöhler wrote his first letter to Berzelius and the correspondence thus begun ended only with the latter's death in 1848. Replying to Wöhler's letter, telling him of the discovery of artificial urea, Berzelius[13] says:

[11] J. J. Berzelius, "Textbook of Chemistry," 1831. Translated from Swedish into German by F. Wöhler, vol. **4**, Part I, 356.

[12] Ninth year, p. 266 (1831).

[13] O. Wallach, "Correspondence between J. Berzelius and F. Wöhler," Leipzig, vol. **1**, 208 (1901).

Like precious gems, aluminum and artificial urea—two very different things coming so close together—have been woven into your laurel wreath.....You have certainly made an important and magnificent discovery and I cannot find words to describe my pleasure at learning about it. It is quite remarkable how the salt-like character completely vanishes when the acid and ammonia combine. Future theories will certainly find this a very illuminating fact.

Another letter from Berzelius,[14] containing an interesting reference to the urea synthesis, should not be passed over. It was occasioned by the following circumstance. In 1830 Wöhler analyzed a certain lead ore from Mexico, the results of which caused him to suspect the presence of an unknown substance. Illness, however, prevented him from completing the work. Meanwhile Sefström announced the discovery of vanadium. At once Wöhler realized that he had just missed discovering this new element himself. Marking a specimen of his material with an interrogation mark, he sent it to Berzelius. The latter's reply is quite humorous so far as vanadium is concerned, but his commendation of his former pupil's recent researches must have allayed in great measure Wöhler's chagrin at having missed such a splendid opportunity. This letter runs as follows:

In reference to the specimen sent by you under an interrogation mark, I will relate the following story. In the remote regions of the North there dwells the goddess Vanadis, beautiful and fair. One day there was a knock at her door. The goddess was weary and thought she would wait to see if the knock would be repeated, but there was no repetition, and whoever it was went away. Curious to see who it could be to whom it appeared to be a matter of so little importance whether he was admitted or not, the goddess ran to the window to look at the retreating figure. "Ah!" said she to herself, "it is that fellow Wöhler. He deserves his fate for the indifference he showed about coming in." A short time afterward there was another knock at the door, but this time so persistent and energetic that the goddess went herself to open it. It was Sefström who appeared at the threshold, and thus it was that he discovered vanadium. Your specimen is, in fact, oxide of vanadium.

Then Berzelius adds: "But the chemist who has discovered a way to produce an organic body artificially, can well afford to forego all claims to the discovery of a new metal." All these quotations from Berzelius clearly show what he thought of Wöhler's synthesis of urea and they hardly seem to bear out the statement that he attached more importance to the example of isomerism presented by the urea synthesis than he did to the synthesis itself.

Yet, important as he no doubt considered Wöhler's discovery, apparently Berzelius did not look upon this formation of urea as a synthesis. This is to be inferred from one of his letters wherein he expresses his opinion as to the formation of oxalic acid from cyanogen. As translator of Berzelius' textbook and *Jahresbericht*, Wöhler now and then wrote for infor-

[14] E. Hjelt, "Selections from the Letters of F. Wöhler to J. J. Berzelius," Berlin, **1884,** p. 37.

mation about doubtful points and one of these queries was the following:[15] "You say that oxalic acid cannot be put together from its elements. Possibly there might be an objection that it can be formed from cyanogen and aqueous ammonia." Wöhler no doubt had in mind the formation of oxalic acid, which he has himself described in his papers[16] of 1824 and 1825, and evidently he regarded the formation of this acid from cyanogen and ammonia as a synthesis. Berzelius,[15] however, seems to have been of the opposite opinion, as his reply shows: "The passage referred to should read that oxalic acid cannot be put together directly from its elements, that is, from carbon and oxygen." In as much as urea is also formed from cyanogen and ammonia together with oxalic acid, Berzelius could not have regarded it as having been synthesized in the sense that it had been put together from its elements. If we were to restrict organic synthesis to the narrow limits set by Berzelius, we should have few syntheses to talk about, for in how many instances are organic compounds made directly from their elements? Even living organisms do not so synthesize the organic compounds they produce.

Berzelius was not more appreciative of Wöhler's discovery than were other chemists of note. In Germany no chemist enjoyed a more intimate association with Wöhler than did Liebig, then at the beginning of a distinguished career. The long correspondence of these two men affords many proofs of their mutual respect and admiration. Nor did Liebig confine to private correspondence his high opinion of his collaborator's genius. At the meeting in 1837 of the British Association for the Advancement of Science held in Liverpool, Liebig[17] presented a paper in which he says concerning Wöhler's synthesis of urea: "The extraordinary and to some extent inexplicable production of urea without the assistance of the vital functions, for which we are indebted to Wöhler, must be considered one of the discoveries with which a new era in science has commenced." Then Liebig points out the significance of this discovery and concludes with a comment on the state of organic chemistry in England in these words:

> There are many bodies similar to urea, all of which will probably at a future period be produced by artificial means; but in order to arrive at this, the final object of investigation in organic chemistry, a great deal of labor, and that labor of a combined nature, will be required. I am certain that this object will be attained. Organic chemistry has made its first step and already its field has been extended to a surprising

[15] O. Wallach, "Correspondence between J. Berzelius and F. Wöhler," Leipzig, vol. **1,** 449 (1901); also p. 454.

[16] F. Wöhler, *Kongl. Vetens. Akad. Hand.*, **1824,** 328; and *Pogg. Ann.*, **3,** 177 (1825).

[17] Justus Liebig, "On the Products of the Decomposition of Uric Acid," *Notes and Abstracts of Communications to the Brit. Assoc. Adv. Sci.*, **1837,** p. 38.

degree. We meet every day with new and unexpected discoveries. It is, however, remarkable that in the country in which I now am, whose hospitality I shall never cease to remember, organic chemistry is only commencing to take root.

Hofmann,[18] who, as a pupil of Liebig, met Wöhler in the Giessen laboratory and probably more than once heard his synthesis of urea talked over, throws further light upon contemporary opinion when he says in his obituary of Wöhler:

> This synthesis of urea is in the true sense of the word an epoch-making discovery. With it was opened to investigation a new field of which chemists did not hesitate to take possession. The present generation, which daily reaps rich harvest on this field conquered for it by Wöhler, can transport itself only with difficulty to those remote times when the formation of an organic compound in the body of the plant or animal seemed to be brought about in a mysterious manner by the vital force, and it is able therefore hardly to realize the sensation produced upon their minds by the building up of urea from its elements.

Chemists actively engaged in research in 1828 seem to have been notably abundant in France. The names of Gay-Lussac, Dumas, Thénard, Laurent, Chevreul, and others at once come to mind in connection with that period. Most eminent undoubtedly was Gay-Lussac who was closely associated with Wöhler's synthesis of urea. To say that he was the original cause of this synthesis may be no exaggeration, for his discovery of cyanogen[19] in 1815 was the beginning of a number of researches upon cyanogen compounds that engaged the attention of chemists in France and elsewhere. Apparently Gay-Lussac wrote nothing about the synthesis of urea, but Pelouze, his former pupil and assistant, in a letter to Liebig expresses the opinion French chemists in general had of Wöhler. In writing to Wöhler about this letter, Liebig[20] says: "Parisians are wild over our benzoyl paper." Pelouze writes: "In Paris the chemical world talks of nothing but your researches. Come here with Wöhler and receive the tribute of honor you have justly earned. Kindly give my compliments to your friend Wöhler and express to him my very great admiration."

Another chemist high in the annals of French chemical research was Dumas. In one of his papers[21] he writes as follows about the synthesis of urea: "All chemists have applauded the brilliant discovery by Wöhler of the artificial formation of urea." And in 1882 Dumas[22] informed the

[18] A. W. Hofmann, "In Memory of Friedrich Wöhler," *Ber. deut. chem. Ges.*, **15,** 3127 (1882).

[19] J. L. Gay-Lussac, "Researches upon Prussic Acid," *Ann. Chim. Phys.*, 1st Ser., **95,** 136 (1815).

[20] A. W. Hofmann, "Correspondence of J. Liebig and F. Wöhler from 1829–1873," Braunschweig, vol. **1,** 75 (1888).

[21] J. B. Dumas, "On the Composition of Urea," *Ann. Chim. Phys.*, 2nd Ser., **44,** 273 (1830).

[22] *Compt. rend.*, **95,** 571 (1882).

French Academy of the great loss they had sustained by the death of their illustrious foreign associate Wöhler in these words:

His contemporaries have not forgotten the universal astonishment produced by the unexpected discovery which enabled him by purely chemical methods to prepare artificial urea, the most highly nitrogenized of animal substances. Since that time other transformations, or combinations, giving rise to substances hitherto met with only in animals or plants, have been brought about. Yet the artificial formation of urea still remains the neatest and most elegant example of creations of this kind.

Dumas then concludes with these personal remarks:

The Academy will pardon me for indulging in a very personal recollection. Wöhler and I were born in 1800. I was his senior by a few days. We both entered upon our scientific careers at the same time and for more than sixty years everything, as Wöhler

Photo from the medal loaned by Frau Ruth Hückel, Göttingen, Germany

MEDAL PRESENTED TO WÖHLER ON HIS 80TH BIRTHDAY

recalled to my mind on a recent occasion, contributed to make closer these ties of brotherhood.

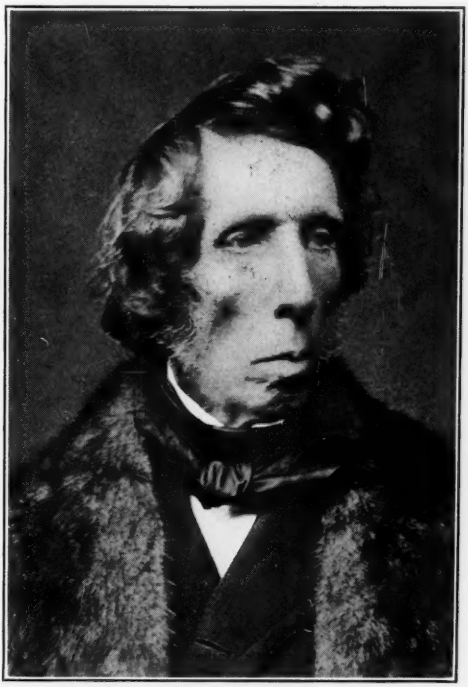
In 1838 Pelouze[23] made a most interesting reference to Wöhler's synthesis of urea. This is in connection with a paper on the action of water on cyanogen published in 1818 by Vauquelin.[24] As a result of this experiment, Vauquelin could not have avoided forming urea, for five years later (1823) Wöhler prepared urea in this way in Berzelius' laboratory, designating it as a *peculiar crystalline compound* in a paper published in 1824, which I have called the true date of the urea synthesis, in the Proceedings of the Swedish Academy. Pelouze refers to Vauquelin's failure to recognize urea in these words:

[23] Pelouze and Richardson, "Researches on the Products of the Decomposition of Cyanogen in Water," *Ann. Chem. Pharm.*, **26**, 63 (1838).

[24] M. Vauquelin, "On Cyanogen and Hydrocyanic Acid," *Ann. Chim. Phys.*, **9**, 144 (1818).

Had Vauquelin followed up the investigation he began on the action of water on cyanogen, probably he would have been the first to make the wonderful discovery made by Wöhler five years later of the artificial formation of an animal product. But the small quantity of material at his disposal did not permit him to make a complete analysis and he never returned to the subject again.

Apparently Pelouze also looked upon 1824 and not 1828 as the date of the synthesis of urea.



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WÖHLER IN LATER LIFE

Although Vauquelin's failure to recognize urea reflects no particular discredit upon him, it does perhaps make Wöhler's success the more noteworthy. In this connection it may not be out of place to include another hitherto unmentioned case where urea was overlooked. In 1812 John Davy[25] prepared phosgene from chlorine and carbon monoxide. Describing the behavior of the new gas with ammonia, Davy says: "Mixed

[25] John Davy, "On a Gaseous Compound of Carbonic Oxide and Chlorine," *Phil. Trans., Royal Soc.*, London, **104,** 144 (1812).

with ammoniacal gas, a rapid condensation took place, a white salt was formed, and much heat was produced." It was Davy's belief that only one compound had been formed by the union of the two gases. The large volume of ammonia combining with one volume of phosgene greatly surprised him, for he adds: "I have ascertained by repeated trials, both syn-

METAL PLAQUE OF F. WÖHLER

The origin of this plaque is unknown to us. It was the property of Dr. Ira Remsen, who presented it to Mr. William Henry Stewart. It is reproduced here through the courtesy of Mr. Stewart.

thetical and analytical, that the gas condenses four times its volume of the volatile alkali, and I have not been able to combine it with a smaller proportion." Had Davy investigated the product of this reaction as carefully as he did the combining proportion of the two gases, he might have discovered artificial urea by a method quite different from Wöhler's and

by one free from the objection that materials of organic origin had been used. One volume of phosgene does combine with four volumes of ammonia, as Davy found, forming urea (1 mole) and ammonium chloride (2 moles). Urea was synthesized in 1856 by Natanson[26] in this manner but he does not refer to Davy's early experiment. Moreover in a letter to Berzelius in 1832, in which he speaks of his experimental plans with Wöhler, Liebig[27] says: "We hope to produce urea by uniting phosgene with ammonia, thereby establishing it as an amide." Thus Wöhler and Liebig long before Natanson's synthesis of urea from phosgene and ammonia had in mind the possibility of making it in this way, but I have been unable to find any record of their having actually performed the experiment.

Liebig, it will be recalled, told the British Association for the Advancement of Science in 1837 with frankness and truth that organic chemistry was then only beginning to take root in England. The new science, so to speak, was in its swaddling clothes, and therefore to expect to find in English chemical literature many references to Wöhler's synthesis of urea would not be reasonable. Yet in 1832 at the second meeting of the British Association for the Advancement of Science at Oxford, James F. N. Johnston,[28] who had worked in Berzelius' laboratory and was then professor of chemistry at Durham, presented a lengthy report on the progress of chemistry in which he says concerning urea:

> A very interesting discovery lately made by Wöhler, is the artificial formation of urea, obtained in transparent, colourless, rectangular, four-sided crystals, containing the elements of cyanic acid and ammonia, but no ammonia, and possessing all the properties of urea. Wöhler has since succeeded in forming a cyanate of ammonia possessing the characters of a salt.

If organic chemistry had only just begun in England in 1828, it had not made even a beginning in the United States. We were still in the pioneer stage of development and the synthesis by an obscure German professor of such a substance as urea could hardly be expected to awaken much interest. There were few publications in which such a subject could appear. The *Journal of the Franklin Institute* and the *American Journal of Science* (*Silliman's Journal*) were in existence, but the former was too much occupied with practical matters to afford space for an organic synthesis and the latter, though giving considerable space to a paper on the benzoyl compounds written soon after by Wöhler and Liebig, makes no

[26] J. Natanson, "On Two New Artificial Methods of Preparing Urea," *Ann. Chem. Pharm.*, **98,** 287 (1856).

[27] Justus Carrière, "Letters of Berzelius and Liebig from 1831–1845," 2nd edition, Munich, **1898,** p. 47.

[28] James F. N. Johnston, "Report on the Recent Progress and Present State of Chemical Science," *Report Brit. Assoc. Adv. Sci.*, **1832,** p. 524.

mention of the urea synthesis. Reference to it may have been made in some early textbook, which I have not seen, but I doubt if it will be found elsewhere. As late as the close of the last century I heard a distinguished professor of Harvard College refer to the structural formulas of organic chemistry as spider-webs in which the enthusiasts of the new science were entangled. What wonder then that this country has no printed record of interest in Wöhler's urea synthesis, though American chemists here and there may have been aware of the fact that this German professor had made a very significant discovery.

Yet, if Wöhler's American contemporaries failed to leave any appreciative recognition of his urea synthesis, our later organic chemists have not. Of these the name of Ira Remsen is perhaps the most noteworthy. Indirectly he was closely connected with Wöhler, for he was a pupil of Fittig who in turn was a pupil and assistant of Wöhler. He also translated Wöhler's textbook into English. In his obituary of Wöhler written in 1883, Remsen[29] says concerning the urea synthesis:

> In 1828 he made the remarkable discovery that ammonium cyanate is transformed into urea. It would be difficult to exaggerate the importance of this discovery. That a substance like urea, which up to that time had only been met with as a product of processes which take place in the animal body, should be formed in the laboratory out of inorganic compounds appeared to chemists then to be little less than a miracle. Today such facts are among the commonest of chemistry. The many brilliant syntheses of well-known and valuable organic compounds, which have been made during the past twenty years, are results of this discovery of Wöhler.

So far as can be learned from reading personal letters, textbooks, and scientific journals, the only possible conclusion therefore is that Wöhler's contemporaries looked upon his synthesis of urea as a discovery of major importance. Otherwise the most eminent chemists of his time would not have called it epoch-making, nor in referring to it have used such adjectives as brilliant, wonderful, remarkable, unexpected, extraordinary, etc. But, as has already been pointed out, there was nothing else they could say, for they were confronted by a fact that admitted of no difference of opinion. Contrasted with more complex syntheses that were to follow, the urea synthesis appears extremely simple. But simplicity is usually a characteristic of most great discoveries. Far more significant, however, than the synthesis itself is the proof it furnished of the fallibility of the idea that only living organisms could produce organic compounds; and also the encouragement it gave chemists to undertake other syntheses. As has so often been said, the synthesis of urea marked the beginning of a new era, the fruits of which have been far beyond the wildest dreams of the pioneers. For this reason Wöhler's achievement will ever remain memorable so long as organic chemists continue to dream and experiment.

[29] Ira Remsen, "Friedrich Wöhler," *Am. Chem. J.*, **4**, 289 (1882–83).

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WÖHLER'S CARD CLUB

(1) Wöhler; (2) Weber, who in collaboration with Gauss, invented the electro-magnetic telegraph.

Photo loaned by Dr. F. W. Frerichs

WÖHLER'S CLASS IN CHEMISTRY OF ABOUT 1878

Wöhler is in the second row at the right of the center and Frerichs is on his left.

SOME EXPERIENCES OF DR. EDGAR F. SMITH AS A STUDENT UNDER WÖHLER

One evening during the meeting of the American Chemical Society held in St. Louis, April, 1928, a group of chemists (F. B. Dains, H. N. Elsey, E. E. Slosson, and William McPherson) were chatting together in the lobby of Hotel Chase, when Dr. Edgar F. Smith happened along and joined the company. He was in a reminiscent mood and for an hour or so recounted his experiences as a student under Wöhler at Göttingen University. Realizing that Dr. Smith was probably the sole surviving member of the group of American college professors who had studied under Wöhler, one of his listeners (McPherson), on returning to his home, dictated, as nearly as he could recall, Dr. Smith's reminiscences just as he had given them. A few weeks later came the sad news of Dr. Smith's death. Thinking that his student experiences at Göttingen might be of interest to many other friends of Dr. Smith, it has been thought worthwhile to publish an account of them as narrated by him on the occasion referred to above.

First Meeting with Wöhler

"I had been a student at Göttingen University for some weeks before I came into contact with Wöhler. I had been given the problem of preparing several pounds of phosphorus trichloride, and to do this I had to generate considerable quantities of chlorine, which I did in the ordinary way by treating manganese dioxide with hydrochloric acid. After each run, it was my custom to take the large flask containing the residues of manganese chloride out into the yard and pour the mixture down into a sewer. On one occasion when I was bending over pouring out the residues and rinsing out the flask, some one tapped me on the shoulder, and looking up, I saw it was the Geheimrat. He asked me what I was doing. I told him about the problem assigned me and that I was pouring out the residues preparatory to generating more chlorine. He then asked me what the materials had cost me. I replied that I did not have the estimate at hand. He told me to find out the cost and to consult some one in the city connected with a chemical supply store as to whether there was not some market for the manganese chloride I was pouring down the sewer. I soon found there was such a market, provided the chloride was pure. Wöhler then asked me to save my residues and purify the manganese chloride so that I might get some return for the money I was spending for chemicals. Acting upon his instructions, I saved the product, purified it, and showed samples of it to Wöhler. He wished to know what evidence I had for the purity of the compound and particularly whether it was free from iron which was likely to be a constituent of the manganese dioxide I was using. I had to confess that I was not sure of its

purity. He then asked me to make definite tests for iron and if I found the element present to remove it so that I could guarantee the manganese chloride pure. I soon found that iron was present. The problem of removing this impurity without introducing any other was one that caused me considerable thought and study. Finally I hit upon the idea of precipitating the iron with pure manganese carbonate. This method enabled me to obtain C.P. manganese chloride which I sold and in this way received sufficient money to pay for the raw chemicals I was using."

A Christmas Memory

"Two or three days before Christmas the chemical laboratories in the University of Göttingen were nearly deserted. Only a few students remained. Late in the afternoon, some one began singing 'Stille Nacht, Heilige Nacht.' One by one the other students in the laboratory gathered about the singer and solemnly joined in the song. Soon we noticed that the door of the laboratory opened and in walked the old Master. Immediately he took from his head the black skull cap he was accustomed to wear in the laboratories, placed it under his arm, folded his hands, and with bowed head stood just inside the door while the song continued. When the singing was over the old Master came forward and said, 'Thank you, gentlemen,' and withdrew."

The Final Examination for the Ph.D. Degree

"My dissertation had been accepted and I was awaiting notice of the hour and the day for the final examination. The notice came that I was to be examined on a certain Saturday evening at six o'clock. A couple of days before the date of the examination I was walking on the streets of Göttingen and chanced to meet a young German student, large in stature and very imposing, whom I had seen working in the laboratory, although he had never deigned to speak to me. On this occasion, however, when he met me on the street, he stopped and accosted me. According to the custom, I saluted him and waited to hear what he had to say. 'Herr Smith,' he began, 'I notice from the bulletin that you are to come up for your final examination for the Ph.D. degree on next Saturday evening. 'Yes,' I replied, 'I have received notice to this effect.' 'Herr Smith,' continued the young German student, 'do you know how to separate the platinum metals from each other?' I replied I was afraid I did not. The German student continued: 'I have just taken the examination myself. The Geheimrat began by asking me how to separate the metals of the platinum group. Unfortunately I knew nothing about it and after floundering about for some time was told to continue my studies for another six months and then to try the examination again.' 'Herr Smith,' continued the young student, 'it will be to your advantage to know how to

separate the metals of the platinum group.' I thanked him profusely, we saluted each other and went on our ways. I returned to my room, took out of my bookcase a book on Mineral Analysis written by Wöhler, and began studying the chapter dealing with the separation of the platinum metals. There were some twelve pages devoted to this subject, and not making much headway and realizing the time was short, I decided that the best thing for me to do was to commit these twelve pages to memory. I studied late into the night walking back and forth in my room memorizing the chapter. In the morning I continued and found that before the hour of examination came I could repeat the entire twelve pages word for word.

"At the hour of examination, appropriately attired in dress suit and white gloves, I presented myself and was directed to a seat on the platform while the professors sat around and asked questions. Near the end of the examination, the Geheimrat, who was then old and somewhat feeble, straightened himself in his chair and said that he would like to ask the Herr Candidate a few questions. After some hesitancy, he began. 'Herr Candidate, will you tell me how you would separate the platinum metals from each other?' I acted a little confused, picked at the ends of my white gloves to show my confusion and then, somewhat haltingly at first, but becoming more fluent as I proceeded, began to repeat the twelve pages of Wöhler's treatise dealing with this subject. I had not gone very far when the Geheimrat with an air of great satisfaction thanked me profusely and complimented me upon my knowledge of the subject. Thus ended the examination in chemistry.

"There were present at the examination some professors from departments other than chemistry and the chairman inquired if any others cared to ask me questions. Now the regulations of the University required every candidate for the Ph.D. degree to add to his dissertation a brief biography or 'Vita' written in Latin. It was the general custom for a student to pay some one proficient in Latin the sum of $10.00 to translate his 'Vita' for him. However, I had studied Latin a number of years and I wished to save my $10.00, so I sat up all of one night translating my biography into Latin. When the chairman of the examining committee asked if any one else wished to ask the candidate any questions, a very elderly and dignified professor with long white whiskers said that he thought he would like to ask a few questions. I had never seen this professor before and I did not know what was coming. I observed, however, that the bewhiskered professor had three sheets of paper upon which something had been written and I soon became aware that these three pages were the ones on which I had written my 'Vita.' The professor, whom I subsequently learned was one of the most eminent Latin scholars in Europe, said 'Herr Candidate, I notice in your 'Vita' that you use the accusative together with the infinitive construction. Can you quote any rule that

will justify this?' I was able to quote such a rule. The professor then said, 'Can you give me the name of any author who used this construction?' I replied 'Tacitus.' The professor then asked, 'Could you by any chance quote from Tacitus?' Fortunately I was able to do so. The professor continued, 'Have you read the Odes of Horace?' I replied that I had. 'Can you quote from the same?' I was able to do so. The professor continued still further, 'Have you ever read the Ars Poetica?' I replied that I had, recalling with great satisfaction that I had been compelled to commit much of it to memory in my youthful days. 'Can you quote from the same?' I launched forth with great fluency until I was finally told that was sufficient. The examination was continued on the next Monday morning and the Latin professor was again on hand with his questions. Evidently it was rare for him to find any one who had a knowledge of the language and he wished to make the most of it. I do not think I would have been failed, however, because of any lack of knowledge of the Latin language."

The Post-Examination Visit to the Professors

"Following the usual custom, a day or two after the examination I made my formal call on each of the professors. I was received at Wöhler's residence by a servant who told me that he would see if the Master would receive me. A little later the servant returned and ushered me up the stairs to Wöhler's study where I was cordially received. After some formalities Wöhler complimented me upon my answer to the question in regard to the separation of the platinum metals saying that the answer was not only correct but was couched in such perfect language. I replied that it was not my language but his that I used; and then related to him the story of how I happened to commit this part of his text to memory. The Geheimrat took it as a great joke and laughed heartily."

Wöhler's Interest in Students in Elementary Chemistry

"I noticed a young lad in the laboratory working week after week on qualitative analysis. One day the Master came in and, happening to see the lad working rather disconsolately, went over to his desk and asked him what he was doing. The student replied that he was trying to work out the tests for chromium but that he was not getting good results and did not understand the chemistry involved in the results that he was getting. Wöhler then asked him to get out his several beakers and seating himself upon the stool in front of the desk, went over the tests one by one with the student, spending over an hour in straightening out his difficulties and arousing his enthusiasm for the work. This incident made a great impression upon me for here was the great Master who had synthesized urea, working enthusiastically with the beginner."

THE MYSTERY OF LIFE*

F. G. DONNAN, UNIVERSITY COLLEGE, LONDON, ENGLAND

During the last forty years the sciences of physics and chemistry have made tremendous strides. The physico-chemical world has been analyzed into three components: electrons, protons, and the electro-magnetic field with its streams of radiant energy. Concurrently with these advances, astronomy has progressed to an extent undreamed of forty years ago. The distances, sizes, masses, temperatures, and even the constitutions of far-distant stars have been ascertained and compared. The evolution of the almost inconceivably distant nebulae and their condensation into stars and star clusters have been unraveled with a skill and knowledge that would have been deemed superhuman a hundred years ago. Amidst the vast cosmos thus disclosed to the mind of man, our sun winds its modest way, an unimportant star, old in years and approaching death. Once upon a time, so the astronomers tell us, its surface was rippled by the gravitational pull of a passing star, and the ripples becoming waves broke and splashed off. Some drops of this glowing spray, held by the sun's attraction in revolving orbits, cooled down and became the planets of our solar system. Our own planet, the Earth, gradually acquired a solid crust. Then the water vapor in its atmosphere began to condense, and produced oceans, lakes and rivers, as the temperature sank. It is probably at least a thousand million years since the Earth acquired a solid crust of rock. During that period living beings, plants, and animals have appeared, and, as the story of the rocks tells us, have developed by degrees from small and lowly ancestors. The last product of this development is the mind of man. What a strange story! Here on the cool surface of this little planet, warmed by the rays of a declining star, stands the small Company of Life. One with the green meadows and the flowers, the birds and the fishes and the beasts, Man with all his kith and kin counts for but an infinitesimal fraction of the surface of the Earth, and yet it is the mind of man that has penetrated the Cosmos and discovered the distant stars and nebulae. Truly we may say that Life is the great mystery and the study of Life the greatest study of all. The understanding of the phenomena of life will surely be the crowning glory of science, towards which all our present chemical and physical knowledge forms but the preliminary steps.

Observing the apparent freedom, spontaneity, and indeed waywardness of many forms of life, we are at first lost in amazement. Is this thing we call life some strange and magical intruder, some source of lawless and spontaneous action, some fallen angel from an unknown and inconceivable

* Read before the British Association for the Advancement of Science, at the Glasgow Meeting, September, 1928.

Universe? That is indeed the question we have to examine: and we may begin our examination in a general way by inquiring whether living things are subject to the laws of energy that apply to the mass phenomena of the inanimate world. The first of these laws, known as the law of the conservation of energy, says that work or energy can only be produced at the expense of some other form, and that there are definite rates of equivalence or exchange between the appearing and disappearing forms of energy. In a closed system we can make up a balance sheet and we find that the algebraic sum of the increases and decreases, allowing of course for the fixed rates of exchange, is zero. That was one of the great discoveries of the nineteenth century. The physiologists have found that living beings form no exception to this law. If we put a guinea pig or a man into a nutrition calorimeter, measure the work and heat produced and the energy-values of the food taken in and the materials given out, we find our balance sheet correct. The living being neither destroys nor creates energy. One part of the apparent freedom or spontaneity of which I spoke is gone. Energy-producing action must be paid for by energy consumed. The living being does not break the rules of exchange that govern the markets of the non-living and the dead.

Another great discovery of the nineteenth century, the so-called second law of thermodynamics, restricts the direction of energy-transformation. Thus a large tank of hot water at an even temperature will not be found to cool itself so that the disappearing heat energy appears as the kinetic energy of a revolving fly-wheel or as the increased potential energy of a raised mass of metal, no other changes of any sort having taken place. Such a transformation need not, however, in any way conflict with the law of conservation. Uncoördinated energy in equilibrium, *i. e.*, of even potential, does not spontaneously transform itself into coördinated energy. Now, it would be a discovery of tremendous importance if plants or animals were found to be exceptions to this rule. But, so far as is known, the facts of biology and physiology seem to show that living beings, just like inanimate things, conform to the second law. They do not live and act in an environment which is in perfect physical and chemical equilibrium. It is the non-equilibrium, the free or available energy, of the environment which is the sole source of their life and activity. A steam engine moves and does work because the coal and oxygen are not in equilibrium, just as an animal lives and acts because its food and oxygen are not in equilibrium. As Bayliss has so finely put it, equilibrium is death.

The chief source of life and activity on this planet arises from the fact that the cool surface of the earth is constantly bathed in a flood of high temperature light. If radiation in thermal equilibrium with the average temperature of the earth's crust were the only radiant energy present, practi-

cally all life as we know it would cease, for then the chlorophyl of the green plants would cease to assimilate carbonic acid and convert it into sugar and starch. The photo-chemical assimilation of the green plant is a fact of supreme importance in the economy of life. This transformation of carbonic acid and water into starch and oxygen represents an increase of free energy, since the starch and oxygen tend naturally to react together and give carbonic acid and water. Such an increase in free energy would be impossible if there existed no compensating running-down or degradation of energy. But this running-down or fall in potential is provided by the difference in temperature between the surface of the sun and the surface of the earth, a difference of some five or six thousand degrees. All living things live and act by utilizing some form of non-equilibrium or free energy in their environment. The living cell acts as an energy transformer, running some of the free energy of its environment down to a lower level of potential and simultaneously building some up to a higher level or potential. The nitrifying bacteria investigated by Winogradsky, and recently by Meyerhof, utilize the free energy of ammonia plus oxygen. By burning the ammonia to nitrous or nitric acid they are enabled to assimilate carbonic acid and convert it into sugar or protein. Other bacteria utilize the free energy of sulfuretted hydrogen plus oxygen. Anaerobic bacteria utilize the free energy available when complex organic compounds pass into simpler chemical compounds.

The close study of these energy exchanges and transformations is becoming a very important branch of cellular physiology and in the hands of Warburg and Meyerhof in Germany, and of A. V. Hill in England, to mention only a few eminent names, has already yielded results of the greatest value and importance. It would be a great thing if one of these investigators were to find a case where the second law of thermodynamics broke down. Up to the present, however, it appears that all these energy transformations of the living cell conform with the second law as it applies to the inanimate world. Thus another part of the apparent freedom or spontaneity of life, of which I spoke before, disappears. A living being is not a magical source of free energy or spontaneous action. Its life and activity are ruled and controlled by the amount and nature of the free energy, the physical or chemical non-equilibrium, in its immediate environment, and it lives and acts by virtue of this. The cells of a human brain continue to act because the blood stream brings to them chemical free energy in the form of sugar and oxygen. Stop the stream for a second and consciousness vanishes. Without that sugar and oxygen there could be no thought, no sweet sonnets of a Shakespeare, no joy, and no sorrow.

To say, however, that the tide of life ebbs and flows within the limits fixed by the laws of energy, and that living beings are in this respect no higher and no lower than the dead things around us, is not to resolve the

mystery. Consider for a moment a few of the phenomena exhibited by living things—the fertilization of the ovum, the growth of the embryo, the growth of the complete individual, the harmonious organization of the individual, the phenomena of inheritance, of memory, of adaptation, of evolution. Viewing these phenomena in the light of the facts known to physics and chemistry it is little wonder that some modern philosophers have followed in the steps of certain older ones and seen in the phenomena of life the operation of some strange and unknown vital force, some "entelechy," some expanding vital impulse; or at least some new and undiscovered form of "biotic" or "nervous" energy. It is difficult to resist the comparison of the developing embryo with the building of a house to the plans of an invisible architect. Growth and development seem to proceed on a definite plan and apparently purposeful adaptation confronts us at many stages of life.

How can the differential equations of physics or the laws of physical chemistry attempt to explain or to describe such strange and apparently marvelous phenomena? The answer to this question was given more than fifty years ago by the great French physiologist, Claude Bernard. We must patiently proceed, he said, by the method of *general physiology*. This is the fundamental biological science toward which all others converge. Its method consists in determining the *elementary conditions of the phenomena of life*. We must decompose or analyze the great mass phenomena of life into their elementary unit or constituent phenomena. That was the answer given by Claude Bernard. It is worthy of a Newton or an Einstein. It sounded the clarion note of a new era of biological science. Today, general physiology in its application of physics, chemistry, and physical chemistry to the operations of the living cell is the fundamental science of life. Patiently pursued, step by step it is beginning to unravel the mystery. The late Professor Bayliss was one of the greatest of the pioneer successors of Claude Bernard in England. Another of the greatest ones was Jacques Loeb in America, whose death we all so deeply deplore. Although it is always invidious to mention the names of living men, it is good to think that in Great Britain today we possess three of the greatest living exponents of general physiology; namely Barcroft, Hill, and Hopkins, while in America the great work of Jacques Loeb is carried on by distinguished men of the high caliber of Lawrence Henderson, Osterhout, and van Slyke. In Germany we have such eminent names as Meyerhof, Warburg, Bechhold, and Höber, to mention only a few. What are these men attempting? Just what Claude Bernard set out in his program; namely by a patient, exact, and quantitative application of the facts and laws of physics and chemistry to the elementary phenomena of life, gradually to arrive at a synthesis and understanding of the whole. That was precisely how Newton was able to determine the motions of celes-

tial objects, namely by going back to the elementary or fundamental law of gravitation.

Through fine analysis to synthesis is indeed the only truly scientific method. I do not mean that general physiology in the pursuit of its studies will not discover many things as yet unknown to us. The future findings of this science may be as strange to the investigators of today as the relativity theory of Einstein and Minkowsky was to the physicists of a few years ago. What I do mean is that the future discoveries and explanations of general physiology will be continuous and homologous with the science of today. Should indeed a new form of energy, "a vitalistic nervous energy" be discovered, as predicted by the eminent Italian philosopher, Eugenio Rignano, it will be no twilight will-o'-the-wisp, no elusive entelechy or shadowy vital impulse, but an addition to our knowledge of a character permitting of exact measurement and of exact expression by means of mathematical equations.

To give you the barest outline of the progress made by general physiology since the death of Claude Bernard fifty years ago (his statue together with that of Marcellin Berthelot stands in front of the Collége de France), would require at least a hundred lectures and the encyclopedic knowledge of a Bayliss. Permit me, however, to mention one or two examples and those with all brevity. The chemistry and energy changes of muscle cells have been discovered recently by Meyerhof in Germany and by A. V. Hill and others in England. When the muscle tissue contracts and does work, it derives the necessary free energy, not from oxidation, which is not quick enough, but from the rapid exothermic conversion of the carbohydrate glycogen into lactic acid. When the fatigued muscle recovers, it recharges its store of free energy; that is to say, by oxidizing or burning some of the carbohydrate, it reconverts the lactic acid into glycogen. Thus in the recovery stage we have the coupled reactions of exothermic oxidation of carbohydrate and endothermic conversion of lactic acid into glycogen. Everything proceeds according to the laws of physics and chemistry. The story of this mode of action and recovery of the muscle cells forms one of the most fascinating chapters of modern science. Here we see one of the elementary phenomena of life already to a great extent analyzed and elucidated. How this would have rejoiced the heart of Claude Bernard! This is one of the examples which I wished to mention.

Another is what I may call the blood equilibrium. The red blood cells are enclosed in a membrane which does not allow the hemoglobin to escape and only permits of the passage of inorganic anions, though water and oxygen can pass freely in and out. Between the red cells and the external blood plasma in which they are submerged there exists a whole series of delicate exchange equilibria, such as water or osmotic equilibrium, ion-distribution equilibria, etc. The entrance of oxygen, which

combines with the hemoglobin, converts it into a stronger acid and ejects carbonic acid from the bicarbonate ions within the cell. Any disturbance of one of these equilibria produces compensating changes in the others. The whole series of equilibria can be written down in a set of precise mathematical equations. Thus two of the most important elementary phenomena of many forms of life, namely respiration and the exchanges of the red blood cells, have been analyzed, subjected to exact measurement, and described by exact mathematical equations. The laws of physics and chemistry have again been found to hold good. The beautiful story of this blood equilibrium we owe to the labors of many distinguished physiologists, but chiefly to Lawrence Henderson and van Slyke in America, and A. V. Hill and Barcroft in England. That is the second example I wished to mention. These two will suffice for my present purpose.

What is the lesson to be drawn from them? No less than that the elementary phenomena of life are *deterministic*, that is to say, that events compensate or succeed each other just as in the physico-chemical world of inanimate things, and that their compensations and successions can be exactly measured and expressed in the form of precise mathematical equations. Determinism exists just as much or, if you please, just as little, in the elementary phenomena of the living as in those of the non-living systems familiar to physics and chemistry. Claude Bernard maintained that this was so. To the imperishable luster of his name be it said that fifty years of exact research have borne witness to the truth of his faith. Please do not misunderstand me here. True science should have no dogmas. It would have been a wonderful and a fine thing if recent research in general physiology had led to a non-deterministic sequence of phenomena in the elementary condition of life. During the last fifteen years theoretical physics, which has been undergoing a period of unexampled and daring advance, has dropped many a hint of the existence of apparently non-deterministic systems. The audacious springs of the electron within the atom, from one energy level to another have often appeared to be ruled by considerations of relative probability rather than by any exact determinism in the ordinary sense of this word. But we cannot as yet be sure of anything in modern theoretical physics. The feet of the young men are too swift upon the hills. Just as we now hear little of the jumping frog of Calaveras County, so modern wave mechanics has rather overwhelmed the discontinuously jumping electron, and seems to offer more promise of determinism than did that uneasy ghost. Thus, determinism, in the rigorous sense of the term, is no infallible dogma of science. It would not be surprising if it did not exist in the minute phenomena of the world, since the apparent determinism of events on a greater scale is often only the result of a very high degree of statistical probability.

Be that as it may, the investigations of general physiology, so far pursued, indicate that the elementary phenomena of life are quite as fully deterministic as phenomena on a corresponding scale of magnitude in the inanimate physico-chemical world.

Let us now make the daring supposition that general physiology, following the lead of Claude Bernard, has eventually succeeded in quantitatively analyzing every side and every aspect of the elementary condition of life. Would such a supposedly complete and quantitative analysis give us a synthesis of life? That is one of the most fundamental and most difficult questions of biological science. A living being is a dynamically organized individual, all the parts of which work harmoniously together for the well-being of the whole organism. The whole appears to us as something essentially greater than the sum total of its parts. This aspect of the living individual was fully recognized by Claude Bernard. It has been emphasized recently by General Smuts in his remarkable book on Holism and Evolution. Life, as seen by General Smuts, is constantly engaged in developing wholes, that is to say, organized individualities. We may indeed learn how the regulative and integrating action of the nervous system, so beautifully and thoroughly investigated by that great physiologist, Sir Charles Sherrington, serves to organize and unite together in a harmonious whole the varied activities of a complex multicellular animal. We may learn, too, how those chemical substances, the hormones, discovered by Bayliss and Starling, are secreted by the ductless glands and, circulating in the *milieu interieur* of an animal, act as powerful means for harmoniously regulating and controlling the growth and other activities of the various organs and tissues.

Nevertheless, in spite of these great discoveries, the harmonious and dynamic correlation of the various organs and tissues of a living organism ever confronts us as one of the great mysteries of life. In an inanimate physico-chemical system we think, if we know the situations, modes of action and inter-relations of the component parts, whether particles or waves (or both), together with the boundary conditions of the system, that we have effected a complete synthesis of the whole. Though very crudely expressed, some such view as that lies at the basis of the Newtonian philosophy which rules our thought in the inanimate physico-chemical world. Is the organized dynamical unity of a living organism something fundamentally new and different? Confronted by a problem of this order of difficulty, it behooves us to be patient and to await the future progress of scientific research. Perhaps if we could actually witness and follow out the varied motions and activities of a single complex chemical molecule in a reacting medium we might find something not so very different from life. Or perhaps the organic unity of a living organism requires for its understanding some such explosion of human

thought and inspiration as that which occurred when Einstein and Minkowsky discovered the true relations of what we call space and time. We may, however, be sure of this: the understanding, when it comes, will consist in something that permits of exact measurement and of precise expression in mathematical form, even though for the latter purpose a new form of mathematics may have to be invented.

Leibnitz once remarked that "the machines of nature, that is to say, living bodies, are still machines in their smallest parts *ad infinitum*." Anatomy and histology have progressively disclosed the structure of living things. Histology has revealed to us the cell with its nucleus and cytoplasm as the apparently fundamental unit of all organs and tissues. What is contained within the membrane of a living cell? Here we approach the inner citadel of the mystery of life. If we can analyze and understand this, then the first great problem—perhaps the only real problem—of general physiology will have been solved. The study of the nature and behavior of the living cell and of unicellular organisms is the true task of biology to-day.

The living cell contains a system known as protoplasm, though as yet no one can define what protoplasm is. One of the fundamental components of this system is the class of chemical substances known as proteins, and each type of cell in each species of organism contains one or more proteins which are peculiar to it. Important components of the protoplasmic system are water and the chlorides, bicarbonates, and phosphates of sodium, potassium, and calcium. Other substances are also present, especially those mysterious bodies known as enzymes, which catalyze the various chemical actions occurring within the cell. Strange to say, the living cell contains within itself the seeds of death, namely those so-called autolytic enzymes which are capable of hydrolyzing and breaking down the protein components of the protoplasm. So long, however, as the cell continues to live, these autolytic enzymes do not act. What a strange thing! The harpies of death sleep in every unit of our living bodies, but as long as life is there their wings are bound and their devouring mouths are closed.

This protoplasmic system exists in what is known as the colloid state. Roughly speaking, this means that it exists as a rather fluid sort of jelly. There is something extraordinarily significant in this colloid state of the protoplasmic system, though no one as yet can say what it really means. Recollecting the statement of Leibnitz, one may be sure that the protoplasmic system of the cell constitutes a wonderful sort of mechanism. There must exist some very curious inner structure wherein the protein molecules are marshaled and arrayed as long, active mobile chains or columns. The molecular army within the cell is ready for quick and organized action and is in a state, during life, of constant activity. Oxidation, assimilation, and the rejection of waste products are always going on.

The living cell is constantly exchanging energy and materials with its environment. The apparently stationary equilibrium is in reality a kinetic or dynamic equilibrium. But there is a great mystery here. Deprive your motor car of petrol or of oxygen, and the engine stops. Yes, but it does not die, it does not begin at once to go to pieces. Deprive the living cell of oxygen or food and it dies and begins at once to break up. The autolytic enzymes begin to hydrolyze and break down the dead protoplasm. Why is this? What is cellular death? The atoms and the molecules and ions are still there. Meyerhof has showed that the energy content of living protein is no greater than that of dead protein. Has some ghostly entelechy or vital impulse escaped unobserved?

Now it is just here, at the very gate between life and death, that the English physiologist, A. V. Hill, is on the eve of a discovery of astounding importance, if indeed he has not already made it. It appears from his work on non-medullated nerve cells and on muscle that the organized structure of these cells is a *chemo-dynamic* structure, which requires oxygen, and therefore oxidation, to preserve it. The organization, the molecular structure, is always tending to run down, to approach biochemical chaos and disorganization. It requires constant oxidation to preserve the peculiar organization or organized molecular structure of a living cell. The life machine is therefore totally unlike our ordinary mechanical machines. Its structure and organization are not static. They are in reality dynamic equilibria, which depend on oxidation for their very existence. The living cell is like a battery which is constantly running down and which requires constant oxidation to keep it charged. It is perhaps a little premature at the present moment to say how far these results will prove to be general. Personally, I believe that they are of very great importance and generality, and that for the first time in the history of science we begin, perhaps as yet a little dimly, to understand the difference between life and death and therefore the very meaning of life itself. Life is a dynamic molecular organization kept going and preserved by oxygen and oxidation. Death is the natural irreversible breakdown of this structure, always present and only warded off by the structure-preserving action of oxidation.

The next great problem which I shall venture to consider in this brief sketch concerns the origin of life. It might indeed be argued with much justice that such considerations are so far beyond the present stage of science that they are entirely without value. That, I think, is a bad argument and a worse philosophy. But, in any case, a dealer in mysteries is entitled to carry on his dealings as far and as best he may.

There appear to be two schools of thought in speculations of this character. The late Professor Arrhenius supported the theory or doctrine of *Panspermia*, according to which life is as old and as fundamental as in-

animate matter. Its germs or spores are supposed, on this view, to be scattered through the Universe and to have reached our planet quite accidentally. You will remember that Lord Kelvin suggested they were carried here on meteorites. But against this idea the objection has been urged that meteorites in passing through our atmosphere get exceedingly hot through friction with the air. Arrhenius brought forward the very ingenious idea that the motion in and distribution through space of these germs or spores were caused by the pressure of light, which in the case of very minute bodies can overcome the attraction of gravitation, as is often seen in the tails of comets. Many objections have been brought against this theory of Panspermia. It has been argued that either the cold of interstellar space or the ultra-violet light which pervades it would be sufficient to kill such living spores. Certainly ultra-violet light is a very powerful germicide, though many spores can withstand very low temperature for long periods of time. Perhaps the chief objection to this doctrine of Panspermia is that it is a hopeless one. Not only does it close the door to thought and research, but it introduces a permanent dualism into science and so prejudges an important philosophical issue.

If the living has arisen on this planet from what we regard as the non-living, then various extremely interesting points arise. It is already pretty certain that life originated, if at all, in the primeval ocean, since the inorganic salts present in the circulating fluids of animals correspond in nature and relative amounts to what we have good reason to believe was the composition of the ocean some hundred million years ago. The image of Aphrodite rising from the sea is therefore not without scientific justification. We have seen that life requires for its existence a certain amount of free energy, or non-equilibrium, in the environment. In the early atmosphere there was plenty of carbon dioxide, and probably also some oxygen, though nothing like so much as at present. Volcanic action would provide plenty of oxidizable substances, such, for example, as ammonia or sulfuretted hydrogen.

As we have seen previously, certain bacteria could therefore in all probability have lived and assimilated carbon dioxide, producing organic substances such as sugar and proteins. This argument, though very interesting from the point of view of Panspermia, has a serious flaw in it from the present point of view, since the bodies of these bacteria would necessarily contain the complicated organic protein of the protoplasm. When the earth cooled down to a temperature compatible with life, it is probable that the ocean contained little if any of such organic substances or their simpler organic components. There was likewise no chlorophyl present to achieve the photo-chemical assimilation of carbon dioxide. Hence the necessity of considering how organic substances could have arisen by degrees in a primeval ocean originally containing only in-

organic constituents. The late Professor Benjamin Moore took up this question and endeavored to prove that colloidal iron oxide, in the presence of light, moisture, and carbon dioxide could produce formaldehyde, a substance from which sugar can be derived. This work of Moore's has been actively taken up and developed by Professor Baly in recent years. He has conclusively proved that, in the presence of light, moisture, and carbon dioxide, formaldehyde and sugar can be produced at the surface of certain colored inorganic compounds, such as nickel carbonate. We may therefore conclude that the production of the necessary organic substances in the primeval ocean offers no insuperable obstacle to science.

But there is still a very great difficulty in the way, a difficulty that was pointed out by Professor Japp at a former meeting of the British Association in Dover. The protein components of the protoplasmic system are optically active substances. As is well known, such optically active substances, *i. e.*, those which rotate the plane of polarization of plane polarized light, are molecularly asymmetric and always exist in two forms, a dextro-rotatory and a levo-rotatory form. Both these forms possess equal energies and so their formations in a chemical reaction are equally probable. As a matter of fact, chemical reactions always produce these two forms in equal quantities and so the resulting mixture is optically inactive. How then did the optically active protein of the first protoplasm arise? In spite of many attempts to employ plane or circularly polarized light for this purpose chemists have not, so far as I know, succeeded in producing an asymmetric synthesis; *i. e.*, a production of the dextro- or levo-rotatory form, starting from optically inactive (that is to say, symmetrical) substances. The nut which Professor Japp asked us to crack has turned out to be a very hard one, though there is little reason to doubt that it will be cracked sooner or later. Even were this accomplished, very formidable difficulties still remain; for we have to imagine the production of the dynamically organized and regulated structure of living protoplasm. Professor Guye of Geneva has in recent years offered some very interesting speculations concerning this difficult problem. According to the statistical theory of probability, if we wait long enough, anything that is possible, no matter how improbable, will happen. All the ordinary events of life happen frequently because they are very probable, while the improbable things happen on an average relatively rarely. The celebrated miracle of the "typewriting monkeys" may be cited as an example. If six monkeys were set before six typewriters and allowed to hit the keys at their own sweet will, how long would it be before they produced—by mere chance—all the written books in the British Museum? It would be a very long, but not an infinitely long time.

Now the second law of thermodynamics, to the scrutiny of which we subjected the phenomena of life, is purely a law of statistical probability.

The odds against Mr. Home, the celebrated medium of former days, levitating without any compensating work or energy effect, are enormously heavy. The uncoördinated energy in and around Mr. Home might indeed spontaneously convert a part of itself into the coördinated energy of Mr. Home rising majestically into the air, but the safe odds against that happening are simply terrific. The ordinary large scale happenings of the world, with which we are so familiar, are simply events where the odds-on are gigantically enormous. The coming down of Mr. Home with a bump is an event on which we could safely bet, with an assurance of success quite unknown in racing or roulette. The theory of probability tells us that there always exist fluctuations from the most probable event. In the physico-chemical world of atoms, molecules, and waves these fluctuations are ordinarily imperceptible, owing to the enormous number of individuals concerned. In very small regions of space, however, these fluctuations become important and the second law of thermodynamics ceases to run. We have seen that the structure of living protoplasm is extraordinarily fine and delicate. Do events happen here which are to be classed as molecular fluctuations, or even as individual molecular events, rather than as the mass probabilities which have led men to formulate the second law? Something of that sort was probably in the mind of Helmholtz when he doubted the application of this law to the phenomena of life, owing to the fineness of the structures involved. The reasoning of Guye bears rather on the origin of life. Is the spontaneous birth of a minute living organism, he asks, simply a very rare event, an exceedingly improbable fluctuation from the average? This is a fascinating point of view, but it possesses one drawback. What is there to stabilize and fix this rare event when it occurs? Guye has, himself, realized this difficulty, but it may not be an insurmountable one. Such rare fluctuations may occasionally cause matter and energy to arrive at peculiar critical points where and whence the curve of happening, the world space-time line, starts out on a different path, and a new adventure arises in the hidden micro-cosmos.

If life has sprung from the non-living, its earliest forms must have been (or must be?) excessively minute. We must look for these, if any where, in those queer things that the bacteriologists call the "filterable viruses." These are living bacteria so exceedingly small that not only are they invisible in the finest microscopes but they pass easily through the minute pores of a Pasteur-Chamberland porcelain filter. D'Herelle has recently discovered the occurrence in certain bacterial cultures of what he calls the "bacteriophage." These seem to be excessively minute organisms which can hydrolyze certain ordinary bacteria. They constitute an extremely fine and filterable "virus." Quite recently Bechhold and Villa, in the Institute for Colloid Research at Frankfurt, have devised a new and ingenious method whereby these minute organisms can be rendered visible

and measured. The process consists in depositing gold on them, strengthening up these gilded individuals as one enlarges the silver particles in an insufficiently exposed negative, and obtaining as end result a sort of metallic skeleton of the original organism. It appears that the individuals of D'Herelle's bacteriophage are small discs whose diameter lies between 35 $\mu\mu$ and 100 $\mu\mu$. Now the diameter of an ordinary chemical molecule is of the order of 1 $\mu\mu$, *i. e.*, one-millionth of a millimeter. If it be proved beyond all doubt that they are really living organisms, then the individuals of D'Herelle's bacteriophage are comparable in size with known colloid aggregates of non-living matter. This result gives rise to strange hopes. If we can find a complete continuity of dimensions between the living and the non-living, is there really any point where we can say that here is life and there is no life? That would be a daring and perhaps a dangerous theme to dwell on at the present time. But where there is hope there is a possibility of research. And who will set a limit to the discoveries that are possible to science in the future?

I hope no reader of this meager sketch of mine will call me a materialist or a mechanist. All I have endeavored to show, however briefly and inadequately, is that the sincere and honest men who are advancing science, whether in the region of life or death, are those who measure accurately, reason logically, and express the results of their measurements in precise mathematical form. A hundred or a thousand years from now mathematics may have developed far beyond the extremest point of our present-day concepts. The technic of experimental science at that future date may be something undreamed of at the present time. But the advance will be continuous, conformal, and homologous with the thought and reasoning of today. The mystery of life will still remain. The facts and theories of science are more mysterious at the present time than they were in the days of Aristotle. Science, truly understood, is not the death, but the birth, of mystery, awe, and reverence.

Warns against Mercury Poisoning from Amalgam Tooth Fillings. Poisoning from mercury used in amalgam tooth fillings has become a serious menace, according to Dr. Alfred Stock, professor in the Technical High School at Karlsruhe. Dr. Stock has conducted investigations and finds that a large percentage of the mercury from these fillings is absorbed by the system. The worst offenders are the mercury-copper amalgams.

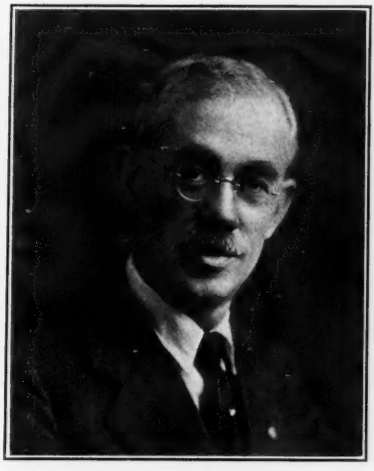
Unfortunately, people have become careless about the dangers of mercury poisoning, and in many walks of life this constitutes a severe menace to health and life itself. Dr. Stock urges a return to the earlier caution observed in the handling of this toxic substance, and suggests that science should be able to find a substitute for mercury in amalgam fillings.—*Science Service*

AN OUTSTANDING HIGH-SCHOOL DEPARTMENT OF CHEMISTRY

W. M. BLANCHARD, DE PAUW UNIVERSITY, GREENCASTLE, INDIANA

With no thought whatever of suggesting invidious comparison but only in the hope of stimulating a deeper interest in the problem of giving our boys and girls a challenging introduction to chemistry, the readers of THIS JOURNAL are invited to consider the method of instruction and the physical equipment provided by Shortridge High School of Indianapolis.

The head of this department, Frank B. Wade, is a man of long experience as a teacher and one who possesses rare skill in exciting and cultivating an interest in his subject. He is widely known not only as a teacher of unusual ability, but also as a chemist and as an expert on precious stones. He has represented the Indianapolis Section in the Council of the American Chemical Society, has been president of the Indiana Academy of Science, and has always taken an active part in the annual meetings of the science teachers of his state. He has sent a large number of students to our colleges and universities; many of them are now occupying prominent positions in educational institutions and in chemical industry.



FRANK B. WADE

A modest presentation of the plan by which Professor Wade leads his students into the field of chemistry follows a brief description of the splendid new laboratory into which he has recently moved—a fitting reward for distinguished services of the past, an inspiration to greater efforts now and in the future.

Equipment

The new building of Shortridge affords the chemistry department more space than has been available in recent years. There are three laboratories, each accommodating a maximum of twenty-four pupils at a time. This limit is built into the laboratories in several ways so as to make almost impossible the crowding of pupils into larger sections than those of twenty-four each. Thus a good deal of individual attention can

always be given to the pupils. There is a classroom with lecture table for demonstration work. In the rear of the room is a departmental library with separate doors for entrance and exit, to prevent disturbing classes in the room. Another classroom with small lecture table is also available. A large stockroom is built in between two of the laboratories and across the corridor from the lecture rooms.

The day's program includes four double periods in chemistry. There are four hundred thirty-two individual drawers for apparatus in the three

Photo by W. W. Bonns, Indianapolis

ONE OF NEW LABORATORIES WITH ACCOMMODATIONS FOR TWENTY-FOUR PUPILS

laboratories; thus it is desirable that the department keep that number of pupils as a maximum.

Alberene stone desk tops and bottle shelves have been specified. In addition to the four hundred thirty-two lock drawers there is a sufficient number of open drawers at every desk so that apparatus to be used by every pupil on occasion are right at hand. Waste-jars convenient to every pupil are provided beneath the desks. The sinks are of the square type and so located that the pupils will have least lost motion. Both d. c. and a. c. current are available for each pupil at his own place. Sectional bookcases for notebooks are kept on special shelves near the door so that pupils may take their notebooks on entering the room and

leave them on going out. Key boards for each section are located near the doors. Balances are kept on shelves along the outer walls of the laboratories.

Instruction

The department conducts five double periods per week (eighty-five minutes per day) for thirty-eight weeks. This arrangement was obtained for all the laboratory science courses of the school through the influence of Charles W. Eliot of Harvard University while on a visit to Indianapolis many years ago. He was at that time professor of chemistry at Harvard.

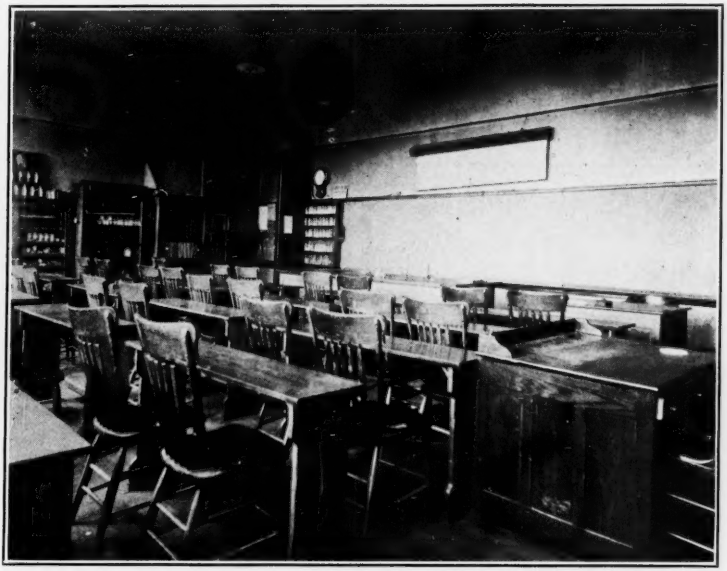


Photo by W. W. Bonns, Indianapolis

CLASSROOM WITH LECTURE TABLE FOR DEMONSTRATION WORK

The conscious purpose of the department is not to teach chemistry, but to try to train boys and girls to use their heads in connection with the study of some few of the fundamental facts and laws and theories of general inorganic chemistry.

To this end the beginnings of all the topics, so far as possible, are made in the laboratory; classroom discussion and then write-up of the work follows. When a particular topic has been covered in this way, the textbook and the reference texts are consulted. This is done almost entirely in the department and under supervision. A large departmental library is kept available to all the pupils and they are taught to use it. Written

examination next follows, more as a teaching exercise than as a test. The questions are framed to compel the pupils to make use of what they should have learned, not to find out whether they have memorized the facts. This method is very slow and not much ground can be covered in a year. However, what is covered is learned thoroughly and there is not much duplication when pupils take beginning college chemistry. Those pupils do not have all the newness taken off their college work. The few fundamentals which they do learn in high school can very well stand the review of the college course and at the same time the college professor will go more deeply into some of the topics. For those who do not go to college the discipline of the course as taught is invaluable and they get enough chemistry to have a very good idea of what it has done, is doing, and may be expected to do for modern civilization. Most of the topics in the Standard Minimum Outline of the American Chemical Society Committee on Education are covered.

The order of treatment of the work is original. At the outset the chemistry of "Earth, Air, Fire and Water" is studied, beginning with the action of air on hot metals; then in the rusting of iron the gain in weight of the oxidizing metal is noted by the pupils, and they reason out that something is taken from the air. The loss of volume of the confined air above the rusting iron again gives them an argument that something is taken from the air in rusting. A candle is next used and its products on burning are caught, studied, and the weight taken to prove gain in weight during burning. The human body is next likened to the candle and its products seen to be similar (water and carbon dioxide), and the production of heat and an elevated temperature in both the case of the candle and that of the body is noted. Decaying leaf mould next is studied and the production of heat and carbon dioxide noted. Thus the oxidation of heated metals, the rusting of iron, the burning of fuels, and the combustion in the body and in decay are all related to the oxygen in the air.

Oxygen itself is next studied as a natural sequence. Also carbon dioxide and monoxide and the properties and uses of these gases are of course considered. The air is then further explored and its oxygen removed. Here the gas laws and calculations to changed conditions must be taught. The residual nitrogen is then studied, followed by the rare gases.

Water is next taken up and studied as a substance and as a solvent, and the laws of solution and the idea of equilibrium in solution are set forth. Then decomposition of water (as steam with hot iron, first) is brought about (active metals next) and the presence of hydrogen discovered. Quantitative composition by volume and by weight comes next and the dual character of the hydrogen of water is brought out by displacement with sodium, followed by displacement of the second portion of the hydrogen with hot zinc dust acting on the residual sodium hydroxide.

As hydrogen was discovered by the pupils in water, it is next prepared in quantity and studied. Thus as natural a sequence as possible is used throughout rather than a systematic order. The pupil thus proceeds always from the known to the unknown.

Much time is put on the development of the atomic theory from the facts of the laws of definite and multiple proportions, and sample cases of definite proportions are shown by comparison of accurate analyses made by the teachers for every beginning section, using the synthesis of magnesium oxide as an example. The weight composition of water as shown by many analyses and syntheses is another case of definite proportions that is used.

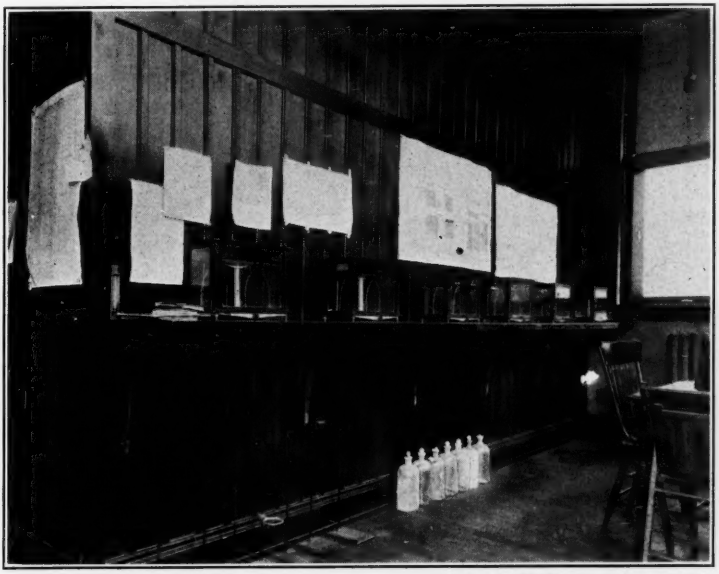


Photo by W. W. Bonns, Indianapolis

ANALYTICAL BALANCES FOR CHEMISTRY III

Hydrogen peroxide versus water, carbon dioxide versus the monoxide and other cases of multiple proportions are then cited. The atomic theory is then offered as an adequate explanation of these sets of facts. The Gay-Lussac gas law is next set forth with the case of the volume composition of water as a basis. The volume composition of hydrogen chloride and of ammonia gas are given as additional material. It is shown that the atomic theory does not serve to explain the Gay-Lussac law. The Avogadro hypothesis is then offered and shown to be an adequate explanation of the gas laws, and use is then made of it to obtain molecular weights and for-

mulas. No use of formulas is made until the atomic theory and the Avogadro hypothesis give adequate basis for them. Thus a real understanding of the significance and origin of formulas can be given to the better pupils.

For many years the department has segregated one or more groups of the twenty-four better pupils after the first semester and put them through a more rigorous course in the second semester. It has been found to be good both for the brighter ones, who get harder competition, and for the weaker ones, who are not discouraged by the speed of the better pupils.

In the last six weeks of the second semester these brighter pupils are given project work in committees of two to four pupils. The committees use the library and read up on their topics, then look up experimental work, perform it, visit factories or other plants as need may require, and report to the class on the complete result of their study. In the last two or three weeks some original research of a simple nature is often done by the better groups.

A third semester of chemistry is offered each spring semester to a few pupils who have proved to be especially capable and who desire to get positions as assistants in commercial laboratories for a year or so to earn money to go to college. This Chemistry III course is one in the fundamentals of quantitative analysis. While no qualitative analysis has been done by these pupils, it is found that they can readily study the reactions employed in the quantitative work as they proceed, and the industrial men who employ these boys and girls are a unit in demanding this sort of work. The pupils learn to be neat and careful, to wash their glassware clean, to be strictly honest in their work, to use the analytical balance rapidly and accurately, and to comprehend standard solutions, the use of indicators, end-point, and so forth. Acidimetry and alkalimetry are, of course taught and some oxidation-reduction reactions are studied. Iodimetry is also given. At present there is more demand for good students in local industrial laboratories than can be supplied.

Industrial Research Willing to Spend Money. The young research chemist in the laboratory of an industrial plant need not fear the displeasure of his chief if he scores a blank, or even several of them, in his efforts to find new products or better processes.

"You will never get into trouble with your directors through conducting unsuccessful research," said L. V. Redman, Vice President and Director of Research of the Bakelite Corporation, speaking before the recent American Institute of Chemistry at Evanston.

"It is when, after having spent ten thousand dollars, you ask for a hundred thousand to take the necessary next step toward industrial exploitation of a bit of research that has been successful that you will need real salesmanship. The million that may be necessary if the industry is to remain in the vanguard these days of progress through research may be no harder to get if the first hundred thousand has been wisely spent."—*Science Service*

THE PROCESSES OF COLOR PHOTOGRAPHY. II. SCREEN PLATE PROCESSES

C. E. K. MEES, EASTMAN KODAK COMPANY, ROCHESTER, NEW YORK

The screen-plate processes of color photography are derived from the suggestion of Ducos du Hauron that the surface of a glass plate or film might be covered with tiny filters—red, green, and blue—and then coated with a color sensitive emulsion. When a photograph is taken through the back of the material, that is, through the color filters, the image will be cut up into little sections, each one of which will be taken through one

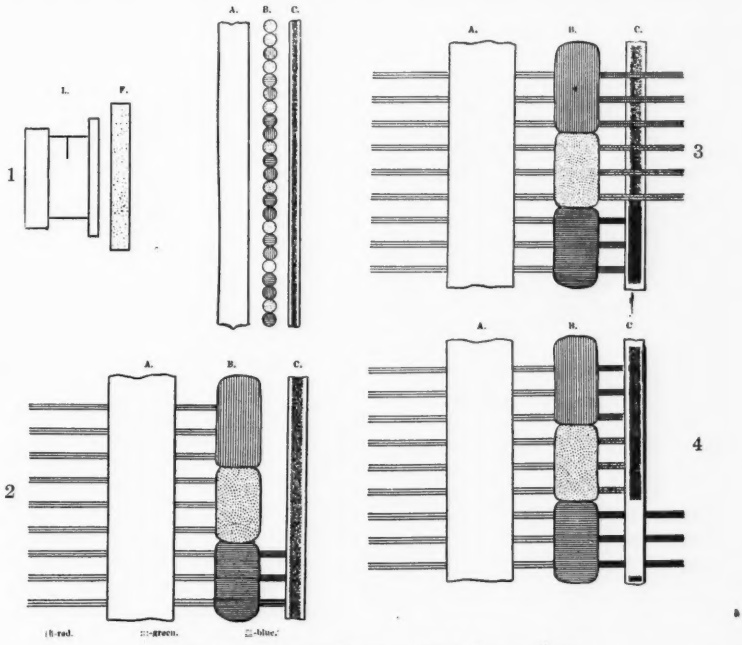


FIGURE 10.—Diagram Showing Use of Screen Plate.

of the three filters, and if the filters are small enough, so that they do not interfere with the vision of the picture as a whole, they will show a color picture. The action of a screen plate is shown in Figure 10 (from drawings by E. A. Salt), in which diagram 1 illustrates the use of the plate as a whole. In this diagram L is the lens and F a compensating filter placed over the lens, by which the greater sensitiveness of the emulsion for blue light is corrected, and equal densities are obtained below the three-unit

filters. The glass plate itself is shown at *A*, the color filters are shown diagrammatically at *B*, and the emulsion at *C*, so that the light from the lens after passing through the compensating filter reaches the back of the plate and passes through the filter units before it reaches the emulsion. In diagram 2, blue light is supposed to fall upon the plate, and, being stopped by the red and green filter units, passes only through the blue filter units, affecting the emulsion, *C*. After development we have the condition shown in diagram 3, white light now being considered to fall upon the plate and to pass through the green and red units and, impeded by the unfixed silver bromide, through the emulsion, while the light falling upon the blue units is completely stopped by the silver which is developed after exposure to blue light. The plate is not fixed after development but is reversed by means of a bleaching solution which removes the silver

FIGURE 11.—Enlargement of Line Screen Plate.

FIGURE 12.—Enlargement of Line Screen Image.

image, the bleaching solution usually being an acid solution of permanganate. After bleaching, the remaining emulsion is developed and is thus blackened under the red and green units, so that, as is shown in diagram 4, the light passing through these units is stopped, and only the light passing through the blue units is able to traverse the emulsion where the silver which was originally developed under those units has been removed by the bleaching bath.

In the earliest attempts to make screen plates, which were made by Professor Joly in Dublin, the color units were lines ruled by means of a pen containing colored ink. Such a screen looks, when magnified, like Figure 11. When a photograph is taken on such a picture, some of the lines are blocked out according to the color which is reproduced, and where one line is more blocked out than another, a color image is obtained, whereas if all the lines are equally blocked out, no color results. An enlargement of an image on such a line screen is shown in Figure 12.

Following Joly, many other attempts have been made to prepare screen plates which might be commercially applied to the production of photographs in color. A great many of these attempts stopped, so far as public records are concerned, at the stage where they were patented; others have progressed to the point where they were publicly announced as being ready for the market; still others have actually been sold; while a few, a very few, have been sufficiently successful to be made for a considerable period. In some types, the screen is prepared to be used with separate panchromatic plates, as was the intention of Joly, while others are made with the emulsions coated actually on the filter screen.

Methods of Preparation of the Filter Screen

1. Ruled Lines.—In addition to the Joly screen, MacDonough, in Chicago, tried to produce screens by this process, the lines being ruled by special machines using very small ruling wheels, but the screens cost too much to produce for commercial success.

2. Dusting-on Methods.—MacDonough also tried this: he coated the surface of a glass plate with a tacky varnish and then dusted on to this small colored particles, such as colored gelatins, shellac, or resins.

Lumière Autochrome. About 1904 there was issued a French patent to the Lumière Company. This was for separating from potato starch the very small grains of the starch, sieving them to pick those of the same size and dividing the grains so obtained in three heaps, each of which was dyed in one of the primary colors; then mixing the three heaps together and dusting them on to glass plates covered with a sticky varnish; then squashing down the starch grains so that they touched each other all over the plate; filling any interstices that might be left with a black powder; varnishing; and then coating the plate with the necessary sensitive emulsion. This was accomplished successfully by the Lumière Company and the plates so made were issued as the "Lumière autochrome" plates, with which most of the color photographs known to the public have since been made.

A photomicrograph of an autochrome plate magnified eighty diameters is shown in Figure 13, and one magnified 500 diameters is shown in Figure 14. So skilfully are the plates made and so exactly are the colors of the separate starch grains, the color sensitiveness of the emulsion, and the color of the compensating filter balanced that the process gives excellent results, while it is by no means difficult to work, and it has thoroughly deserved the wide popularity that it has enjoyed.

The Agfa Process. The Agfa color plates are similar in their appearance to the autochrome plates, but instead of the units being composed of starch grains, they are composed of small colloidal particles which after dyeing are suspended in a medium from which they can be deposited on to the glass.

A similar process has been used by the Lignose Company, who have put on the market roll film and film packs prepared for making color photographs.

3. Printing in Bichromated Colloids.—When such colloids as gelatin, fish glue, etc., are treated with a solution of bichromate, dried and exposed to light, they become insoluble in water. If, then, a glass plate be coated with a solution of bichromated fish glue, and the coated plate be exposed to light under a black line screen which allows only one-third to be exposed at a time, two-thirds being protected by the black lines, and then washed in water, one-third of the entire surface will be covered by lines of fish glue, which can be dyed. After the dye has been mordanted to prevent its running, the plate can be recoated with glue, registered in position on the printing screen, and printed so as to get a second glue line which can be dyed in the second color, provided that the first line has been protected

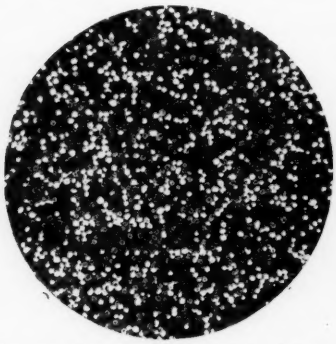


FIGURE 13.—Photomicrograph of Autochrome Plate Magnified 80 Diameters.

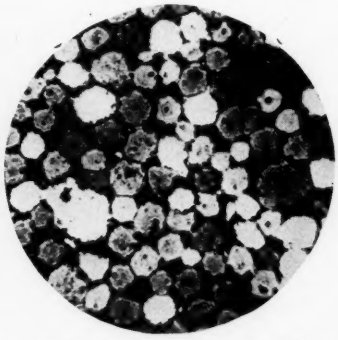


FIGURE 14.—Photomicrograph of Autochrome Plate Magnified 500 Diameters.

from the action of the dye by coating it with a varnish or otherwise. The third line can be printed by exposing the plate through the back, when the first two lines will act as a screen for the third, and in this way we can build up a three-color line screen.

This process has been used by several inventors, notably by J. H. Powrie, by the Thames Company in England, who put screens on the market for a short time, and by the Paget Company, who were successful in competing for some years with the Lumière plates.

4. Screens Made by Section Cutting.—In Germany, Krayn took out a patent for an ingenious process. He took thin sheets of colored celluloid of the three primary colors and piled them on top of one another so as to get a pile of alternate layers of red, green, and blue. By cutting sections down through this pile, sheets of celluloid were obtained made up of strips of each of these red, green, and blue layers. In order to get a screen made of squares instead of lines, Krayn took a pile of his line screens

and stuck them together, and then cut these across again, so that now he had one made up of cubes of the different colors. It was, however, very difficult to make these screens fine enough, and the thickness was also a disadvantage (see Figure 15).

5. Screens Made by Mechanical Printing, or a Combination of This with Dyeing. This will probably be the method by which such screens will be made eventually if the screen-plate processes ever become of great commercial importance, but up to the present no really good screens have been made in this way.

A number of other methods are possible and have been proposed for making the screens, but those already enumerated are the chief.

FIGURE 15.—Photomicrograph of Krayn Mosaic Screen.

The Requirements of a Screen-Plate Process

Assuming that a method has been devised for placing units upon a glass plate or other support, to form a screen, we must consider the following factors:

1. The Size of the Units.— For regular screens these should not be larger than 1/300th inch, nor smaller than 1/600th inch; for irregular grain screens not larger than 1/900th inch nor smaller than 1/2000th inch.

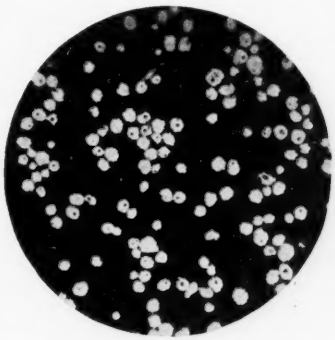


FIGURE 16.—Photomicrograph Showing Clumping of Autochrome Particles.

The units for an irregular grain screen must be smaller than for regular screens because in practice they tend to clump together, so that the effective unit when examined is much larger than the single units (Figure 16). On the average, it may be taken that the effective unit when looking at an irregular grain screen is a clump of ten units, so that the diameter must be made three times smaller than is absolutely necessary from the point of view of invisibility.

Since the resolving power of the emulsion is only just sufficient for use with these small units, if the units are much smaller the emulsion will not be able to resolve them and con-

sequently correct color rendering will not be obtained. The resolving power of the emulsion therefore places a lower limit to the size of the unit which can be employed in a screen plate.

2. **The Interstices.**—If these exist at all, they must be filled in; clear interstices are fatal, even if they occupy only 1/20th of the area of the screen plate.

3. **The Colors of the Units.**—These must be primary red, green, and blue-violet.

4. **The Relative Area Occupied by Each Color.**—These must be adjusted so that the screen as a whole appears neutral.

5. **The Emulsion.**—This must be coated on a varnished surface to protect the screen units from the moisture. The varnishes must be selected so that they will not act upon the emulsion. Turpentine and ether, especially the former, are inadmissible as solvents; resin varnishes are suspect.

6. **The Sensitizing.**—This must be performed so that the actions under the red and green filters are equal.

7. **The Compensator.**—This must be adjusted so that the photographic effect renders grays as grays owing to equality of action through all these filters.

Limitations of Screen-Plate Processes

Beautiful as are the results obtained by the best of the screen-plate processes, these processes have some very marked limitations, especially when applied to portraiture. In order to get sufficient resolving power with reasonably fine units in the screen, the emulsion has to be coated so thinly that the range of gradation which it can render is very limited, and only under the most favorable circumstances is it possible for a screen-plate color picture to reproduce the gradation both in the highlights and in the shadows, so that if a photographer wishes to employ this process, he must limit himself to the subjects for which it is suitable. Moreover, the screens involve a great loss of light, so that the pictures can be seen only with a powerful light behind them, and in as much as they are made by daylight, they should be viewed by light similar to daylight, the results by artificial light being unsatisfactory.

Lightning Stroke Electrocutes Tree. A freak stroke of lightning apparently electrocuted a large white oak tree in the New York Botanical Garden recently. The tree was struck during a thunderstorm, but was not shattered as trees frequently are by lightning. Almost immediately, however, the leaves began to wither, and within a month the tree presented an autumnal appearance against the bright green of the rest of the grove. Continued observation convinced the garden authorities that the tree was dead, and that it had apparently died instantaneously. After it was cut down a ring count gave its age at approximately 200 years.—*Science Service*

AN OLD COLONIAL MANUSCRIPT VOLUME RELATING TO ALCHEMY*

C. A. BROWNE, BUREAU OF CHEMISTRY AND SOILS, WASHINGTON, D. C.

Among the many colonial documents relating to the early history of alchemy in America, which are preserved in the library of the Massachusetts Historical Society in Boston, there is an ancient manuscript volume of folio size written in various handwritings upon paper which is now crumbling to pieces with age. The work comprises a collection of various English and Latin tracts upon alchemy, many of them in verse, which belonged originally to John Winthrop, Jr., the first Governor of Connecticut, and, after passing through various generations of his descendants, was finally donated to the Massachusetts Historical Society by Robert C. Winthrop in 1869. This antique volume, which from indications was transcribed some time in the second half of the sixteenth century before printed books upon alchemy were at all common, might be called almost the Magna Charta of chemistry in America. It was brought to this country when most of the land within the present borders of the United States was an unsettled wilderness and its pages, annotated by the early patrons of chemistry in New England, form a visible connecting link between present-day chemistry of America and medieval alchemy of Europe.

The old Winthrop alchemy manuscript is of English origin and may perhaps have once belonged to that famous alchemist and mystic, Dr. John Dee, the fourth centenary of whose birth has recently occurred. Many of Dee's books were acquired by John Winthrop, Jr., and some of them, copiously inscribed with annotations of the old doctor, can still be seen in the Winthrop collection of books owned by the Society Library of New York City. It is known that Dr. Dee was a prodigious collector of manuscripts upon alchemy and many of these afterward passed into the possession of that famous antiquary, Elias Ashmole. The latter no doubt used some of these writings in compiling his well-known "Theatrum Chemicum Brittanicum," which is a collection of old English poetical treatises upon alchemy, published at London in 1652. Ashmole has included in this compilation the chemical testament of Dr. Dee and in the commentary to his work has given an interesting account of Dee's career as an alchemist.

Several of the alchemistic poems in the Winthrop manuscript folio, such as Thomas Norton's "Ordinall of Alchemy," the "Liber Patris Sapientiae," and Sir Geo. Ripley's "Mystery of Alchymists," are found in Ashmole's "Theatrum Chemicum," although numerous minor differences in spelling and words show that variations had crept into the text of these ancient

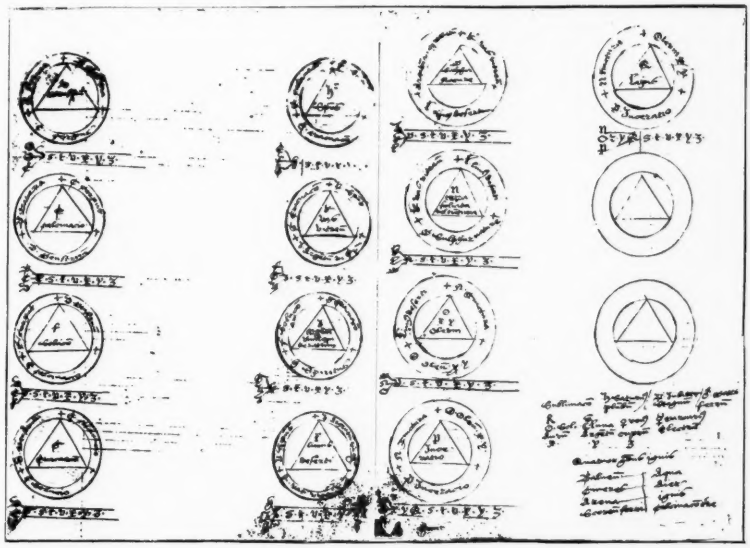
* Read before the Section (now Division) of History of Chemistry of the American Chemical Society, Baltimore, Md., April 9, 1925.

treatises since the time of their composition. The Winthrop folio is indeed one of the surviving examples of the large mass of alchemistic manuscripts which existed in England before the year 1600. Ashmole writes that he consulted no less than fifteen manuscript copies of Norton's "Ordinall of Alchemy" in preparing his edition of the text of this poem. He made similar comparisons of texts in the case of other poems, going back in some cases to documents written in the fifteenth century, nearly two hundred years before Ashmole's time, the "Streames of Learning," as this old antiquarian states, containing "the least of mixture nearest the spring-head." We know from Ashmole's notes what a wealth of old alchemistic manuscripts existed in England three hundred years ago. Yet he leads us to infer that these were only a fragment of the vast number which existed previous to the dissolution of the monasteries and the destruction of libraries under Henry VIII.

There are several alchemistic poems in the Winthrop folio which are not contained in Ashmole's collection. In fact we know from the preface or prolegomena of his collection that the part printed was only a first volume. "More are designed," he writes, "in a Second Part to follow and compleate this a full Theatrum; the which, God allowing me further Time and Tranquillity to run through it, as I have already this, I intend shortly to make ready for the Presse." It is regrettable that Ashmole never published this second volume of his collection for he might have preserved there many other interesting specimens of chemical lore which are now lost. The volume selected for publication, he writes, "is sheav'd up from a few gleanings in part of our English fields; where though I have bestowed my industry to pick up here and there, what I could finde in my way, yet I believe there are many other Pieces of this Nature in private hands, which if any are pleased (out of the same ingenious score that I have published these) to communicate to me, I shall set thereon a value suitable to the worth of their Favours and let the World know its Obligation to them besides."

Ashmole speaks of the beautiful figures and decorations which ornamented some of the vellum manuscripts of the old English alchemists. The Winthrop manuscript has very little in the way of embellishments. There are two pages of alchemistic diagrams (Figure 1) consisting of double circles with a triangle in the center and inscribed with various terms of alchemy in Latin to each of which a letter of the alphabet is attached. Thus *A* is Forma; *B*, Materia; *C*, Corpus; *D*, Menstruum; *E*, Calcinatio; *F*, Solutio; *G*, Evacuatio; *H*, Spiritus; *I*, Argentum vivum exuberatum; *K*, Vas vitreum; *L*, Limus deserti; *M*, Sulphur natura; *N*, Terra foliata vel tinctura; *O*, Oleum; *X*, *Y*, *P*, Inceratio; *Q*, Lapis. These sixteen terms, beginning with Form and ending with the Lapis or Stone, represent progressive steps in the various processes of alchemy and the thirteen dia-

grams in which they are inscribed form an advancing series, the regularity of which, however, is broken in several instances by carelessness in transcribing. At the end of the drawings are two blank diagrams which were not filled in, and at the bottom the signs and names of the seven planets with the corresponding metals are written in Latin. Mercury, it should be

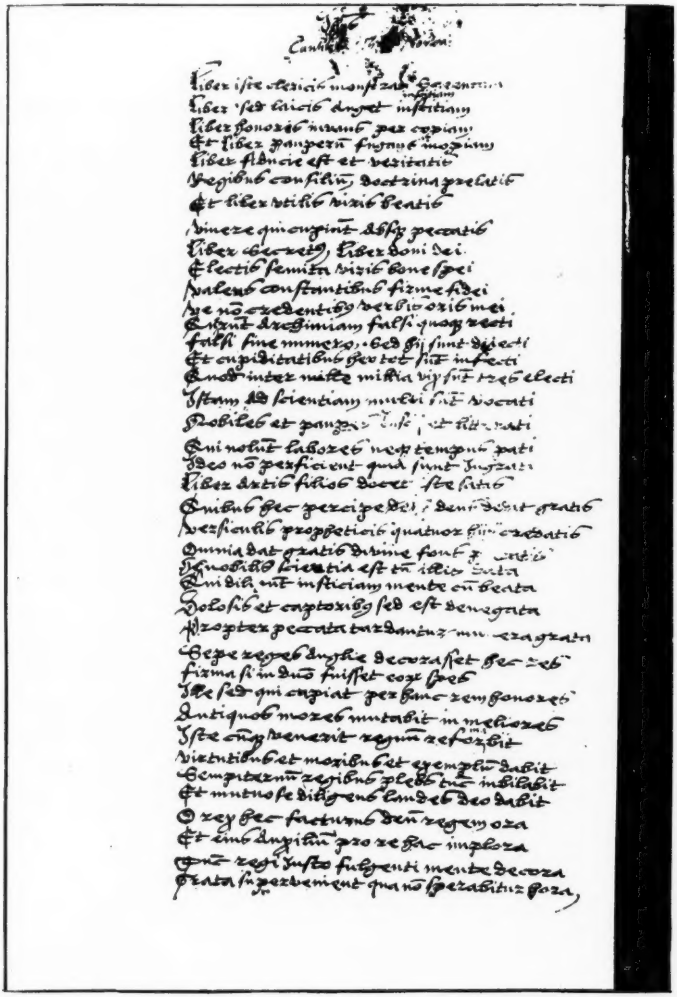


ALCHEMISTIC DIAGRAMS IN THE WINTHROP ALCHEMY MANUSCRIPT OF BOSTON

In the first diagram between the concentric circles are the words *A*, Forma; *B*, Material; *C*, Corpus; and within the triangle *D*, Menstruum; below the circle the letters of the diagram, *A*, *B*, *C*, *D*, are grouped together, followed by the 6 letters, *S.T.V.X.Y.Z.*, which are common to all the 13 diagrams. The second diagram has between the circles *B*, Materia; *C*, Corpus; *D*, Menstruum; and within the triangle *E*, Calcinatio, while below is the diagram group of letters, *B*, *C*, *D*, *E*, and the common line group, *S.T.V.X.Y.Z.* The progression of letters and terms is continued through the remaining diagrams as noted in the text. In drawing these diagrams the copyist made mistakes in placing 7 before 6, in omitting the *M* term in 11 and 12 and in duplicating the *O* term in 11 and the *P* term in 12.

noted, is assigned to the metallic alloy electrum in place of quicksilver (Figure 2).

The Winthrop manuscript bears slightly obliterated parallel lines arranged in groups of four against a vertical head line which might indicate that the paper was originally ruled for music and that afterwards an attempt had been made to remove these rulings by chemical treatment. The long-continued effect of the adhering traces of such chemicals may



PHOTOGRAPH OF A LATIN POEM IN RHYME FROM THE WINTHROP ALCHEMY MANUSCRIPT IN BOSTON

It bears the title Ignis and underneath in a later hand the annotation Cantilena Thomas Norton. The same poem is given identically on pages 2 and 4 of Elias Ashmole's "Theatrum Chemicum Britannicum" as the Latin introduction of Thomas Norton's "Ordinall of Alchemy." It begins with the line "Liber iste clericis monstrat scientiam."

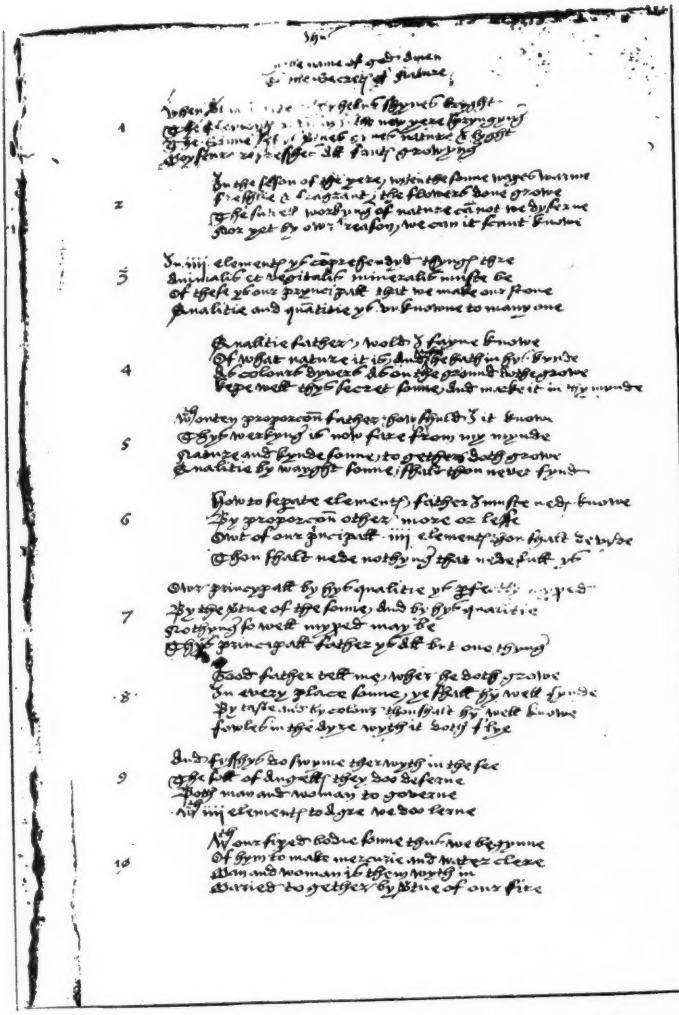
possibly explain the disintegration of the paper and the almost complete disappearance of the ink on many pages of the manuscript.

A detailed account of the text and subject matter of the old Winthrop folio cannot be given until it has been subjected to a careful examination. The most interesting of these manuscripts are those in old English, as they represent the alchemistic ideas which were current in England between the fourteenth and sixteenth centuries and which were composed in the vernacular of that period.

There are two famous old classics of English literature which deal with alchemy. Chaucer's "Tale of the Canon's Yeoman," written about 1385, and Ben Jonson's "Alchemist," published in 1610. It was in the interval between these two compositions, when our language was undergoing its transition from the middle period of Wyclif and Chaucer to the early modern period of Shakespeare and Jonson, that the English alchemical poems in Ashmole's "Theatrum" and in the Winthrop folio were composed. In this plastic formative period, before custom had set its seal upon what constituted good usage, there was no uniformity in spelling, construction, or in the use of words. The writers of this time seemed to be experimenting with the language so that there is no consistency on the part of any one author in the matter of spelling, inflection, or order of words. Ashmole, in reproducing the old text of the poems in his "Theatrum," felt it necessary to speak a few words of apology upon this point. "The style and language thereof," he writes, "may, I confesse (to some) seeme irksome and uncouth and so it is indeed to those that are strangers thereunto. . . . Posterity will pay us in our own coyne, should we deride the behaviour and dresse of our ancestors. . . . And therefore that the truth and worth of their workes might receive no diminution by my transcription, I purposely retain'd the old words and manner of their spelling, as I found them in the Originalls (except only some palpable mistakes and blemishes of former transcribers, which I took upon me to correct and purge as little more than litterall imperfections)."

As an example (Figure 3) of this old English style of chemical composition the following 24 lines are quoted from the commencement of a poem which in the Winthrop folio is entitled "Of the Secrets of Nature" and which is published on page 380 of Ashmole's "Theatrum" as "The Mystery of Alchymists composed by Sir Geo. Ripley Chanon of Bridlington." In the Winthrop folio the poem is written in numbered verses of four lines each. Ashmole, whose text differs† in places from the Winthrop manuscript, makes no attempt to separate the subject matter into verses, but does indicate the divisions of the dialogue between father and son beginning with line 13.

† Variations in Ashmole's text, minor differences, such as those in spelling, excepted.



PHOTOGRAPH OF THE FIRST TEN VERSES OF SIR GEORGE RIPLEY'S POEM IN OLD ENGLISH UPON "THE MISTERY OF ALCHYMISTS" FROM THE WINTHROP ALCHEMY MANUSCRIPT IN BOSTON

The complete poem with numerous textual variations is given on pages 380 to 388 of Elias Ashmole's "Theatrum Chemicum Britannicum."

In the name of God Amen

Of the Secrets of Nature

1. When *Sol in Ariete* and Phebus shynes bryght
The elements reviving, the new yere spryngyng
The sonne by his virtues gyves nature and lyght
Moysture refreshes all fruts growyng[1]

2. In the season of the yere when the sonne waxes warme
Freshlie and fragrant the flowers doue growe
The sutell workyng of nature cannot we dyserne[2]
Nor yet by our reason we can it scant knowe[3]

3. In iiij elements ys comprehendyd thyngs thre
Animalis et vegitalis mineralis muste be[4]
Of these ys our principall that we make our stone[5]
Qualitie and quantitie is unknowne to many one.

4. Qualitie, father, wold I fayne knowe,
Of what nature it is and what he hath in hys kynde
As colours dyvers as on the ground dothe grow[6]
Kepe well thys secret, sonne, and marke it in thy mynde.

5. Withouten proporcion, father, how should I it knowe[7]
Thys werkyng is now fare from my mynde
Nature and kynde, sonne, together doth growe
Qualitie by wayght, sonne, shalt thou never fynd.

6. How to separate elements, father, I muste neds knowe[8]
By proporcion other more or lesse,[9]
Out of our principall iiij elements thou shalt devyde[10]
Thou shalt nede nothyng that nedefull ys.[11]

Ashmole writes of the decayed condition of many of the old manuscripts which he examined. In this connection he states with pardonable pride, "Some of these, pieces (now brought to publique light) had wellnigh perish'd in a silent ruine; and Destruction got a compleate victory over them, but that my diligence and laborious inquisition rescued them from the jawes thereof; being almost quite shrouded in the Dust of Antiquity and involv'd in the obscurity of forgotten things, with their leaves half Worme-eaten. And a wonder it is, that (like the Creatures in Noah's Arke) they were hitherto so safely preserved from that Universall Deluge, which (at the Dissolution of Abbies) overflowed our greatest libraries."

[1] "And moysture refresheth all things growing."
[2] "Of Nature's subtill working we cannot discerne."
[3] "Nor yet by our reason we can it not know."
[4] "Animalls, Vegetabills, Mineralls must be."
[5] "Of this is our Principle that we make our stone."
[6] "As colours divers which on the ground do grow."
[7] "Without proportion, father, how should I it know."
[8] "To separate elements, father, I must needes know."
[9] "Either in proportion which be more or less."
[10] "Out of our Principle foure elements thou shalt draw."
[11] "Thou shalt neede nothing else that needefull is."

The old Winthrop alchemy folio preserved in Boston is in much the same state of destruction as that described by Ashmole for some of the manuscripts of his time. The paper of some of the leaves has so far disintegrated that nothing is left; other pages are in so friable a state that the merest touch causes them to crumble; other parts of the volume, although frail, admit of careful handling. In many places the ink has faded so that the writing is barely decipherable. An experiment was tried of photostating a few of the leaves and the writing of the copies came out a strong black. Careful photostating would rescue a great part of the contents of the Winthrop folio and the text could then be gone over carefully and edited—a piece of work which cannot be performed upon the original without great risk owing to the necessity of frequent handling. Unless some means can be taken to preserve this ancient collection of manuscripts, the slow ravages of time will cause their complete destruction.

The Winthrop folio of alchemy manuscripts is the most priceless volume in the history of American chemistry. It came to our shores with the early English colonists, who brought with them the language, literature, laws, and traditions of their old home, and having remained here now for a period of nearly three centuries has witnessed the rise of chemistry in America from the crude practices of alchemy to its present high state of development. This volume was unquestionably a source of great interest to John Winthrop, Jr., and his numerous alchemist friends, containing as it does all the legendary lore of chemistry from the time of its mythical founder Hermes down through the Egyptians, Greeks, and Arabians until the art was finally imparted to the scholars of medieval Europe and England. To the latter country it was carried by such men as Robert of Chester and Roger Bacon and transmitted by them to Ripley, Norton, Dee, and other writers who were the predecessors and ancestors of the English emigrants that colonized the Atlantic seaboard and brought the traditions of ancient chemistry to the New World. It is the duty of American chemistry to rescue this old treatise, so full of historic associations, from oblivion and to ensure in some manner the permanent preservation of its contents.

Deposit of Potash Salts Discovered. Department of Mines at Ottawa announces that potash salts have been discovered in a thick bed of rock salt which was being bored in search of oil and gas at Gautreau village, Westmoreland County, New Brunswick.

The deposit is located in the belt that runs along the Northumberland Straits littoral in which the Malagash deposits lie. The general opinion is that if potash can be found in commercial quantities in the two provinces of Nova Scotia and New Brunswick, the Canadian Maritimes will have an industry of great value to the British Empire.—*Chem. Markets*, **23**, 198 (Aug., 1928).

ONE HUNDRED YEARS OF ORGANIC SYNTHESIS*

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During July of this year it was my privilege to attend the celebration at Darmstadt of two events of the highest importance to chemists and to chemistry generally. They were the celebration of the 125th anniversary of Liebig's birth, and the 100th anniversary of Wöhler's synthesis of urea This year marks therefore the centenary of what may be described as the first synthetic formation of an organic compound, and it is appropriate on this occasion to give a brief review of the progress that has been made since that epoch-making discovery and to trace the effect it has had on the development of organic chemical science. Needless to say, however, in the brief time at my disposal it would be quite impossible for me to do more than touch on the salient features of my theme. Indeed, I propose only to deal with certain specific questions and, incidentally, to show how the replacement of the "type theory" by the "theory of structure" exerted so remarkable an influence on the development of the science.

As a matter of fact Wöhler's synthesis of urea was made in the same year as another very important synthesis which strangely enough passed almost unnoticed. This was the synthesis by Hennell of ethyl alcohol from ethylene. But Hennell's "synthesis" was from ethylene of natural origin whereas Wöhler's synthesis was from cyanic acid which had already been prepared synthetically by Berthollet in 1787. Wöhler's was therefore a true synthesis and it attracted immediate attention because it dealt a heavy blow to the "vital principle" theory so strongly advocated by Berzelius. It is interesting to note that in accordance with Wöhler's own account of his discovery, which he published in 1828 in the *Annales de Chimie et de Physique*, he first prepared urea in 1822 by the action of ammonia on cyanogen but it was only after obtaining the same substance from ammonium cyanate (1828) that he was able to prove its identity with the urea of animal origin. The great partnership of Liebig and Wöhler, a partnership which was destined to have a marked influence on the development and progress of organic chemistry, started with the investigation of cyanic acid and later dealt with the chemistry of benzoyl, one of the most important radicals forming part of the then prevalent theory of types.

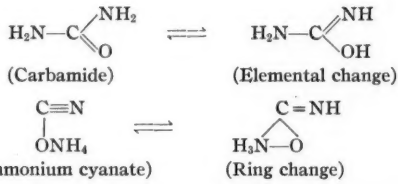
It must be remembered that Wöhler's discovery of the transformation of ammonium cyanate into urea was actually the first example of isomerism; at least it afforded the first recognized example of the existence of two substances having the same molecular weight, and the same percentage composition but having different chemical and physical properties.

* Paper read before the Divisions of Industrial and Engineering Chemistry and Organic Chemistry of the A. C. S., at Swampscott, Massachusetts, September 11, 1928.

Actually, as was shown later by Walker and his pupils, this is not merely a case of isomerism but is also one of tautomerism, since the interchange is reversible and from either side the same equilibrium mixture of the two can be formed.

$$N : C—ONH_4 \rightleftharpoons H_2 : N—CO—N:H_2$$

Indeed the interchange, although rather more complex than the simple type of tautomeric mobility, is none the less such as to fall within the definition of tautomerism as we understand it today. For example, depending upon the formula for urea we may favor, the change can be represented as follows:



Subsequently, many other examples of isomerism were discovered and their discovery dealt the death blow to the theory of types.

There then arose the first conception of the "theory of atomic linkage," a theory which is held at the present time and which has been found to answer in the case of all known organic compounds. It may safely be said that this theory gave an impulse to organic chemistry which has resulted in an advance in the science rarely the outcome of any one theoretical conception. By its means it is possible to show the relationship between different substances, to predict the existence of new compounds, to determine their properties, both physical and chemical, and to foretell the manner in which they can be made. It fails, however, in one all-important particular, because it fails to illustrate mechanism. We can illustrate, for example, the manner in which ethyl acetoacetate can be made. We can determine and illustrate the properties and formulas of the keto and enol forms and we can ascertain the manner in which the one form can be converted into the other to form the equilibrium mixture of the two; however, we cannot illustrate the manner in which this is accomplished nor can we foretell by means of the graphic formulas what, in any given case, the proportions of the equilibrium mixture will be. These are matters concerning the intramolecular movement of the atoms which the "theory of atomic linkage" cannot hope to elucidate.

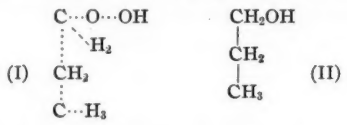
A new theory which may be termed "the theory of intramolecular mobility" is required before questions such as these can be answered. Many such are now being brought forward and there can be no doubt that with the mass of workers now in the field we shall shortly be in a

position to see some little distance ahead so as to get some inkling of the right direction to follow in this fascinating and all-important search. Without doubt the solution lies in finding the right way to apply the electronic theory to the reactions of organic compounds and already much has been done in this connection by the work of Robinson, Lapworth, Ingold, Flürscheim, and others. Great as were the apparent differences between the views of these chemists it would appear that they are largely variations of nomenclature and that gradually the light is shining through and dissipating the fog of new words and phrases, of arrows curved and straight, barbed and unbarbed, which it seems necessary for workers in the field to generate.

The "theory of atomic linkage" or "structural theory" is due in the first instance to the work of Kekulé and Couper (1858), Frankland, Kolbe, and Odling. It was even earlier (1852) advanced by Frankland in his work on the organic-metallic compounds. In this investigation Frankland sought to isolate the free radicals, the existence of which were indicated by the type theory. As is well known, Frankland failed to achieve this object but isolated the organo-metallic compounds; notably zinc ethyl, which he obtained in an attempt to isolate the radical ethyl from ethyl chloride by the action of metallic zinc. The equivalence of atoms, which is the basis of the structural theory, must at that time have been quite clear to Frankland for, in a paper published on May 10, 1852, he says: "that in several compounds of a given element, no matter what the character of the uniting atoms may be, the combining power of the attracting element, if I may be allowed to use the term, is always satisfied by the same number of these atoms." This was, undoubtedly, the first definite statement of the equivalence of atoms.

Nevertheless, the clear enunciation of the theory was in the main due to Kekulé who, in a paper on "The Constitution and Metamorphoses of Chemical Compounds and on the Nature of Carbon" (1858), first definitely discussed the theory; Kekulé showed in the first instance that the chemical units combined with carbon equaled 4. Secondly, in the case of substances containing several carbon atoms it must be assumed that some of the carbon atoms, at least, are held in the same way by the affinity of carbon for itself. Thus in the case of $-\overset{|}{\underset{|}{C}}-\overset{|}{\underset{|}{C}}-$ the carbon atoms have six exposed valencies; *i. e.*, $-\overset{|}{\underset{|}{C}}-\overset{|}{\underset{|}{C}}-$ is hexavalent. Kekulé also pointed out that besides the simple single union, other unions may occur and instanced benzene and naphthalene, subsequently to be elaborated into his benzene theory in 1865. Kekulé's book on organic chemistry, published in

1863, contains a wonderful account of the views he then held and affords a striking example of a man of great genius moulding the knowledge of his time into a new shape, utilizing existing views so as to give effect to his own experimental work and to build the foundations of an edifice which has stood the test of more than 60 years of investigation and research. Indeed this fascinating book of Kekulé's which will well repay those who have the leisure to read it through, must stand, as long as organic chemistry exists, as a monument on the road of progress. Kekulé's formulas were, however, still quite unlike our own structural formulas since, as is to be expected in a textbook intended to be used by students, he does not definitely abandon the "type theory" but seeks to harmonize and modify it in accordance with the views he was elaborating. Couper (1858), as a matter of fact, is to be regarded as the father of our present graphic formulas. For example, Couper wrote propyl alcohol as (I):



which is astonishingly similar to the present formula (II) when it is remembered that Couper regarded oxygen as having an equivalence of 8. Subsequently, Crum Brown and Frankland in 1865 and 1866 evolved the system which is in vogue at the present time.

The effect of the structural theory was at once apparent for, although no further example of the synthetic preparation of an organic substance occurred between 1828 and 1860—if one excepts the entirely empirical synthesis of uric acid by Horbaczewski—the next thirty years witnessed the synthesis of a very considerable number of natural products as well as the preparation and investigation of a vast number of substances not of natural origin but merely definite compounds of carbon, the existence of which was demanded by the structural theory. It is not my purpose to give a detailed account of this extraordinarily prolific period, including as it does the synthesis of alizarine, of uric acid, and of indigo—to mention only three among many others. During this period the organic chemist found himself in the possession of a new weapon by which he was able to attack nature in her most formidable strongholds, wrest from her the secrets she held, and utilize them for the benefit of mankind. Industries based upon the development and utilization of natural products were destroyed and new ones founded on the production of the synthetic substances were created. At the same time the development of the science along structural lines gave rise to the production of many substances of great commercial importance, notably the formation of coloring matters from the aromatic hydrocarbons obtained from the coal-tar distillate—an elabora-

tion of the entirely empirical discovery of the first coal-tar dye, mauve, by Sir William Perkin in 1856.

Hand in hand with the scientific development of the synthetic dyestuff industry went the investigation of medicinal products. For example, successful syntheses of the less complex alkaloids were accomplished, showing the relationship between structure and physiological properties and indicating the means by which other products not of natural origin could be formed. At the same time, new types possessing special medicinal value were produced and utilized for human requirements. From the synthesis by Ladenburg of conine, the essential principle of the hemlock, to the synthesis by Harrington of thyroxalin, the active constituent of the thyroid gland, is a far cry but it embraces a period of great activity and successful endeavor unsurpassed, probably, in the history of any other science. All was not plain sailing and many difficulties were encountered by the pioneers in synthetic organic chemistry. Adolf von Baeyer worked for fifteen years before he was in a position to elaborate a formula for indigo, but once this was done, the synthesis of this valuable natural product quickly followed and its production on the commercial scale occurred shortly afterward. Indeed the earlier pioneers met with many set-backs and disappointments. Thus Baeyer, working on the synthesis of uric acid about the year 1860 (before the "structural theory" had been fully evolved) prepared pseudo-uric acid, which is uric acid having an additional molecule of water. Baeyer was unable to remove this water and abandoned the synthesis as unworkable. Later his great pupil, Emil Fischer, fortified by the "structural theory," and thus knowing that water ought to be eliminated to form the natural compounds, repeated Baeyer's work and found that the very simple process of heating pseudo-uric acid with anhydrous oxalic acid transformed it into uric acid.

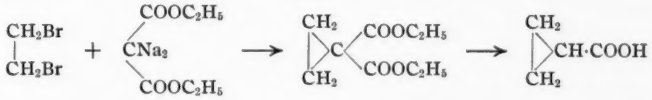
The final period from 1890 to the present day has been equally fruitful in synthesis and production. This period saw the synthesis of camphor by Komppa and also of many other natural substances. The elusive chemistry of camphor had previously puzzled a generation of chemists. Its peculiar properties and its habit of showing itself to be both an aromatic and an aliphatic substance led to many difficulties and troubles. As many as thirty formulas had been proposed for this natural product and, in accordance with the rules followed by the synthetic chemist, every one of them appeared to be reasonable. These rules are quite definite and in nearly every case lead to the correct solution of the problem. The chemist, for example, breaks down the natural substance by one or more of the reagents he has at hand and by identifying the products he can usually rebuild the structural formula in such a way as to enable him subsequently by synthesis to verify it.

In the case of camphor, however, despite the large number of workers, the fragments when put together led to formulas which could not be so verified. Finally, Bredt, by a series of masterly deductions, put forward a formula which fitted in with most of the facts, and the problem of how to prepare a substance of his formula became the question of the moment. W. H. Perkin (the younger), with whom I was working as a research student at the time, rendered Bredt's formula a certainty when we prepared camphoranic acid synthetically but our subsequent attempts to synthesize camphoric acid, the next step, proved abortive, or rather led to the production of but a trace of camphoric acid—a trace so small that only a mixed melting-point determination with a specimen of *rac*-camphoric acid of natural origin could be made. The elegant synthesis of Komppa, which was published almost simultaneously, clearly placed the structure of camphor beyond question and proved conclusively the correctness of the Bredt formula. Komppa not only synthesized camphoric acid but resolved it and later, using the method discovered by Haller involving the addition of potassium cyanide to the reduced camphoric anhydride, converted the *d*-form into *d*-camphor identical with the natural product. Unlike previous syntheses, that of camphor by the Komppa method was far too costly and elaborate for commercial purposes.

Nevertheless, the determinations of the structure of this important natural product indicated a means by which it could be prepared from another natural substance, namely, pinene. The transformation of pinene from oil of turpentine through the oxalate of borneol proved commercially practicable but improvements in the methods of collecting and extracting camphor from the camphor tree led to an increase in purity and a decrease in price of the natural product, so that, as far as I know, the synthetic product, if such it can be called, has ceased to be produced in any great quantity, and in this instance the natural product retains the field. It is possible that had the indigo planters been alive to the danger threatening their industry and had taken in hand, at an early stage, the scientific investigation of their product, the fate that has overcome them might, at least, have been delayed. Still it must be remembered that the standardization of a chemical substance is an all-important factor in its commercial application and that, in the case of a highly complex mixture such as natural indigo, standardization is not only difficult of achievement but costly in operation.

Among the most important discoveries of the last two decades of the 19th century must be placed that of the alicyclic rings made by W. H. Perkin, Jr., working in Baeyer's laboratory. It is fortunate that in the autumn, owing to the establishment of an annual special lecture in memory of Sir Alexander Pedler, we shall be able to hear from Professor Perkin a first-hand account of the history of this most important discovery. The

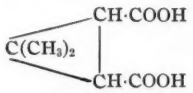
series of three-, four-, five-, and six-membered rings was made by a series of well-known reactions which involved the action of the sodium compound of ethyl malonate on the corresponding straight chain dibromide thus:



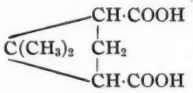
If one studies the literature of this period one is surprised at the controversy the production of these closed carbon rings raised. More especially is this so when one remembers that closed heterocyclic substances of the type of succinic anhydride and acetic anhydride were known and recognized and that the initial idea of a closed ring of carbon atoms had been evolved by Kekulé in his benzene formula, in which the well-known analogy of a serpent with its tail in its mouth was suggested. Indeed the tetrahedral theory of van't Hoff necessitates the assumption that in a chain of five and six carbon atoms the terminal atoms must be very close together and it is reasonable to suppose that under suitable conditions these carbon atoms could be made to unite. Nevertheless, the view was strongly held that these so-called cyclic compounds were actually stable forms of the isomeric unsaturated compounds, despite the fact that they failed to react with oxidizing agents and did not readily add on bromine. Today, of course, this view is no longer held and the alicyclic compounds form an important and definite branch of organic chemistry.

As soon as the existence of these homocyclic compounds became definitely established, Baeyer brought forward his well-known strain hypothesis to account for their existence. Working on the van't Hoff tetrahedral theory, he assumed that the closing of the ring produced strained conditions within the molecule and that this strain was dependent on the alteration of the angle necessary to form the ring. Thus the tetrahedral angle of 109.5° being nearest to the angle of the pentagon (108°), the five-membered ring should be most readily formed and compounds, therefore, of the cyclopentane series would possess the least molecular strain. On the other hand, the double bond, which, in this sense, may be regarded as a ring of two carbon atoms, required the greatest strain for its production and then, in order, followed the cyclopropane and cyclobutane complexes. Beyond the five-membered ring the annular angle becomes greater than the tetrahedral angle of 109.5° and, in consequence, the strain is produced by the opening out of the tetrahedral angle by ring closure. This strain increases therefore as the number of carbon atoms composing the ring is augmented; thus the cycloheptane ring would be more difficult of formation than the cyclohexane complex, cyclooctane than cycloheptane, etc.

Many facts supported Baeyer's hypothesis, mainly in the cyclopentane and cyclohexane series but, on the other hand, many of the reactions of the cyclopropane and cyclobutane derivatives appeared to be abnormal. In fact, derivatives of the cyclopropane series appeared in many cases to be more readily produced than the corresponding compounds in the cyclobutane series. For example, caronic acid can be readily produced whereas no one has yet succeeded in preparing norpinic acid. Many attempts have been made to do so, however, because this acid is of the highest importance as a factor in the determination of the structure of pinene, representing as it does the inner ring of that important natural substance.



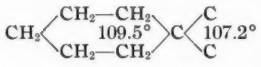
Caronic acid

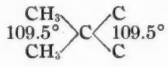


Norpinic acid

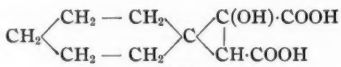
In fact it was clear that the Baeyer hypothesis, although an important expression of a fundamental factor, was yet subject to profound modification by other factors of which it takes no account.

Recent work has shown that the factors producing this modification are two-fold; namely, steric and angular. Both are dependent on the fact that the tetrahedral angle is subject to modification under specific conditions and that if, through any cause, the angle between two valencies is altered, that between the other two valencies is also altered so as to bring about an enlargement or diminution, depending on whether the other angle has been increased or diminished. Thus an enlargement of the tetrahedral angle by the inclusion of a carbon atom in the cyclohexane nucleus (120°) produces a corresponding diminution of the other angle from 109.5 to 107.2°.

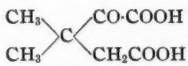




This alteration of the angle, although small, has a remarkable effect on the chemistry of the derivative concerned and a large number of facts have been discovered which illustrate this. It is only necessary to cite as instances, the stability of the hydroxy form of the acid in the cyclohexane series and the stability of the keto-acid in the open chain dimethyl series.



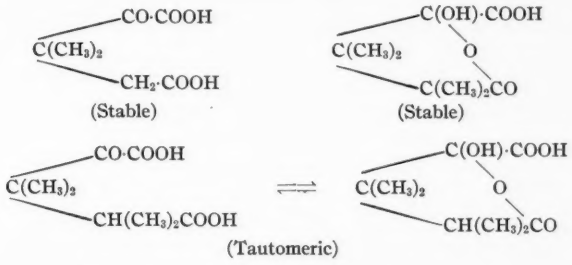
Stable



Stable

The other factor producing an effect on the tetrahedral angle is the volume factor. It has been found for example that in the following series:

the sodium salts are actually tautomeric in strong caustic soda solution, the same equilibrium mixture being produced from either individual by the action of this reagent. Another series illustrating this point in a remarkable manner is that shown by the alkyl keto glutaric acids.



Ruzicska, who has enlarged our knowledge of ring systems in a remarkable way, holds the view that all these systems are strainless or, at any rate, that those above the cyclopentane series, which is itself strainless in the uniplanar form, are rendered so by their existence in the multiplanar state. Thus the cyclohexane ring in the multiplanar condition advocated by Sachse and by Mohr is strainless and in a similar manner the higher membered rings which Ruzicska has prepared and investigated are also strainless. Ruzicska, in a paper he read last month before the International Union of Pure and Applied Chemistry, advocated the view that these large rings were in a looped form and biplanar. It seems unreasonable to assume that these ring systems are not all built up on the same plan and that a general hypothesis should not be applicable to all of them. The chemical and a great deal of the physical evidence, as regards both reactions and ease of formation, is strongly in favor of the strained form for all rings up to that containing six carbon atoms. The seven-membered ring seems to behave as if it were both strained and strainless, but the evidence of the dissociation constants of the dibasic diacetic acids is in favor of the strained condition as is also the evidence of the ease of formation. So far as the higher rings are concerned, we, at present, know so little about them that any conclusions which could be drawn from the evidence at hand is likely to be misleading, but here again the difficulty with which Ruzicska has obtained them and the poorness of the yield seem to point to the occurrence of strain. Moreover, in the case of a C_{17}-membered ring of natural occurrence, such as civitone, in which it may safely be assumed that strainless conditions are present, it must be remembered that the strainless state is

only produced by the inclusion of a double bond and a ketone group in this ring.

The main evidence held to be in favor of a strainless cyclohexane complex has been derived from the preparation of stereo-isomeric forms of the reduced naphthalene compounds such as dekalone, but in this case it must be remembered that locking of the initial six-membered ring occurs through the closing of the second ring in the ortho-position, and that no evidence of this kind, important as it is in connection with the structure of the decahydronaphthalene nucleus, can be accepted as showing the form in which the ring exists before the locking process has been accomplished. The Mohr model of the strainless cyclohexane structure shows it in two forms—one rigid, the other capable of movement about the bonds. The two are not interconvertible and must represent definitely isomeric compounds. No chemical evidence as to the existence of these compounds has been discovered. If, as is suggested, there is interchange between the rigid and non-rigid forms then such interchange can only take place through the uniplanar strained form and in that case it would appear that the resultant effect would be that of a strained ring. In conclusion it is held by many of us that the case of the strainless alicyclic system is not yet proved and that the weight of chemical and physical evidence is, on the contrary, strongly in favor of these substances having the strained structure commensurate with their ring angles. No doubt is entertained as to the uniplanar character of the benzene ring—why then should the uniplanar character of the cyclohexane ring be called in question?

In this very sketchy account of the development of organic chemistry, I have had to leave out many sections which serve as land marks in the progress of the science. I have said nothing of stereochemistry, yet this was one of the most fundamental developments arising from the introduction of the "structural theory" and in the hands of Pasteur, van't Hoff, Pope, and others, has become, probably, the most striking example of its truth. I have said nothing about the carbohydrates, mainly because one of the chief workers in the field has already given you a first-hand account of this important branch of the science.

What then of the future?

The new edition of Beilstein will contain a description of some 400,000 definite compounds of carbon and it is pertinent to ask when additions to this already stupendous list are likely to cease. The answer is that it is never likely to cease and cannot cease so long as fundamental research work in organic chemistry is being carried on. These compounds are not, as certain of our maligners suggest, prepared for the sake of preparing them, but are merely steps incidental to the elucidation of some problem of fundamental importance to the progress of the science. It is absolutely

necessary that these should be recorded in order that subsequent workers in the same field may utilize them as sign-posts indicating the direction along the paths already trodden. In no other way can we hope to explore and map the unknown country ahead of us. I have heard it said that organic chemistry is reaching finality, but to those of us who know, the realization that we have only scratched the surface of things is very evident. Many natural substances such as strychnine, morphine, etc., still evade the skill of the synthetic chemist. The wonderful researches of Willstätter, who has enriched every branch of the science he has touched, have indicated the manner in which the coloring matter of flowers and plants may be investigated, a line which is being followed by Robinson and his pupils. But it is probable that in the immediate future greater attention will be paid to the discovery of the relationship that exists between structure and physical properties, for it is in this way only that we can hope to obtain an insight into the mechanism, not only of reactions but also of the movement of the atoms within the organic molecule. There is evidence that, at last, we are reaching the state when we can apply the electronic theory not only to correlate existing facts but also to predict, and when we attain this end the comprehension of mechanism will not be far off.

In the difficult field of biochemistry the attack from the side of structural organic chemistry—which indeed is the only one which can yield success—must be developed. Already much has been done in this respect but the vast unknown region ahead may well appall the pioneer. The difficulty here is one of method, for the known methods of the organic chemist which have been developed in order to enable him to deal with homogeneous substances seem to fail when applied to the heterogeneous mixtures with which the bio-chemist has to deal. New methods are therefore required and will without doubt be forthcoming. Indeed, it is an open question whether the development of biochemistry does not lie more on the physical side of organic chemistry than on the purely structural side, although it is obviously necessary to know the physical properties of the pure constituents before it is possible to determine the physical characteristics of the colloid mixtures which predominate in the domain of life. Willstätter, with a courage which few of us possess, abandoned the field of synthetic organic chemistry in which he had accomplished so much to take up the study of enzyme action, one of the most important problems of biochemistry. He has found that the greater the purity of the enzyme the less is its physiological action, a remarkable discovery which seems to indicate that biochemical reactions are balanced reactions depending on the presence of secondary substances in the active constituent, and that when these secondary substances are removed then the activity of the enzyme is diminished or ceases. If this is so it is still more apparent

that the problems involved are physico-chemical in character and depend on the physical properties of highly complex colloid mixtures. It is remarkable that the ease with which the yeast enzymes break down glucose into carbon dioxide and alcohol cannot yet be accomplished by laboratory methods.

In conclusion I should say that I have endeavored to show the effect that the introduction of the "structural theory" has had on the development of organic chemistry and to indicate its present-day limitations. We urgently require a new theory which when combined with the structural theory will enable us to define and understand the mechanism of reactions—intermolecular and intramolecular. When this is accomplished an impetus will be given to the development of the science as great as or greater than that imparted by the theory of the structure.

Cotton, Linen, Rayon Act Alike toward Ultra-Violet Rays. The health-giving ultra-violet rays of sunlight, which everybody wants nowadays, pass through cotton, linen, and rayon fabrics about equally well when these are of equal weight and closeness of weave. Fresh, white, natural silk is almost as transparent toward the rays as bleached cotton, while wool is only about half as transparent.

These are some of the results obtained in a study of the transmission of ultra-violet radiation through various fabrics, conducted at the U. S. Bureau of Standards by Dr. W. W. Coblentz, Dr. R. Stair, and Dr. C. W. Schoffstall, and reported in the Bureau's new *Journal of Research*.

"In all cases when the fabric is dyed, or slightly yellowed with age, the ultra-violet transmission through the thread is greatly decreased," the investigators state. "Hence, as is to be expected in comparing various kinds of dyed fabrics, the one having the largest openings between the threads transmits the most ultra-violet.—*Science Service*

Scientific Food Advertisers Must Follow Rules of Science. If advertising would invoke the aid of science it must follow the rules that govern research in science, said Dr. E. V. McCollum of the Johns Hopkins University at the recent meeting in Chicago of the American Public Health Association. Particularly in food advertising, the public is being misled by a wrong use of science.

Dr. McCollum presented a plan for an advisory board to consider food advertising. The board would be composed of eminent scientific men and would only act to advise publishers on strictly scientific matters. This board would decide on questions of accuracy, authenticity, propriety, and applicability of scientific statements in food advertisements. Advertisers themselves are feeling the need of such a board, for the idea was first suggested by John Benson, President of the American Association of Advertising Agencies. Dr. McCollum believes that publishers are also feeling perplexed over the developments in advertising of food products, which have become so extravagant in their claims.

The reason for the fierce competition prompting this wave of so-called scientific advertisements of food is that we are at present eating all we possibly can without harm, says Dr. McCollum. Advertisers, in order to sell more of any kind of food, must take advantage of present scientific knowledge of our nutritional needs. However, too many of them are being led to give the public half-truths in place of scientific facts.—*Science Service*

CONTRIBUTIONS OF CHEMISTRY TO INDUSTRY. PART II*

WALTER A. SCHMIDT, WESTERN PRECIPITATION CO., LOS ANGELES, CALIFORNIA

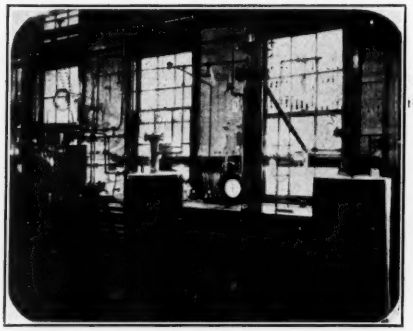
If we go back a hundred years, we find that industry was dependent, with very few exceptions, upon the raw materials which nature either gave or produced, mineral deposits on the one hand and living matter on the other. As was the case in ancient Egypt, our great-grandfathers produced glass, porcelains, enamels, spirituous liquors, soaps, and various concoctions which resulted from the application of numerous formulas. But essentially the industry of the day was dependent upon the direct utilization of the materials which were recovered as such from natural materials or natural products. Let us see what has happened since then.

Probably one of the most interesting industrial contributions of the chemist was the discovery that certain materials in small quantities can be used to stimulate chemical reactions which otherwise would not take place at an appreciable rate under the conditions of operation. The chemist refers to these materials as catalyzers and calls the operation catalysis. This discovery has been applied for the accomplishment of many useful results. For example, if sulfur dioxide gas is mixed with air and conveyed over finely divided platinum at a somewhat elevated temperature, the platinum is not permanently affected, but the sulfur dioxide and oxygen combine to give sulfur trioxide, which, when absorbed in water, gives sulfuric acid, and this sulfuric acid can be produced up to any desired strength. I mention this reaction because it was one of the earliest commercial applications of catalysis. It has led to the building of an enormous number of sulfuric acid plants of much simpler design, and much greater efficiency than was the case with the earlier chamber process, although it must be said that a considerable number of chamber plants are still in operation. Above all it made possible the cheap production of a very strong acid, such as is sold under the trade name of oleum.

More far-reaching in its effect was the discovery of Haber that nitrogen, an exceedingly inert and non-reactive gas, when mixed with hydrogen and subjected to high temperature and pressure in the presence of an appropriate catalyst, reacts to produce ammonia. As it had previously been determined that nitrogen was one of the essential foods of plant life, and whereas practically all of the nitrogen available to man theretofore was brought from the saltpeter beds of Chile, and whereas eighty per cent of the volume of the atmosphere of the earth was nitrogen in an inactive form,

* This paper was prepared for presentation to the Engineers Club of Los Angeles without thought of publication. The paper contains a considerable number of verbatim quotations from various reference books, but as these references were not marked in the original manuscript, their identity has been lost, for which the author offers an apology.

it had been the dream of chemists for years to convert the inactive atmospheric nitrogen into an available form and thus assure an adequate supply for the future. Many dire predictions of future starvation as a consequence of nitrogen shortage were made, and volumes were published painting a dismal picture of the future. The chemist came along and with a simple discovery opened up the storehouse of atmospheric nitrogen. You will be interested to know that Germany, which uses more nitrogen fertilizer per acre than almost any other country, until very recently imported prodigious quantities of Chile saltpeter. Last year, according to published statistics, Germany did not import a single pound of Chile saltpeter, but manufactured all its own nitrogen products, and exported large quantities of nitrogen compounds besides. It is interesting to note that Germany has increased its use of nitrogen as a fertilizer and, by means of this and like increases in the use of potash and phosphates, has brought up its horticultural production to a point where this thickly populated nation is now self-sustaining, so far as food is concerned. It is true that Germany still imports large quantities of food products, but recently I was told by an authority on the subject that the export of horticultural products from Germany to other European nations, now balances the import of food products from the Westgrn Hemisphere. What is true of Germany is also true of other modern nations, and atmospheric nitrogen fixation plants are springing up so rapidly in this country and abroad that it begins to look as though the Chile saltpeter industry might eventually be relegated to the junk pile.



Catalyst testing plant—testing ammonia catalysts.

The ammonia formed by the direct fixation of atmospheric nitrogen can be oxidized, again in the presence of a catalyzer, to nitric acid, and nitric acid, as we all know, is the important chemical necessary for the production of explosives and other nitrification products, such as pyroxylin, lacquers, celluloid, and innumerable other materials now playing an important part in the world's commerce.

Another most interesting application of catalysis is in the hydrogenation of fats and oils. A few years ago we were dependent upon animals for hard fats, such as lard. Liquid fats differ from hard fats usually in that they have a lower hydrogen content. The chemist set out to put more

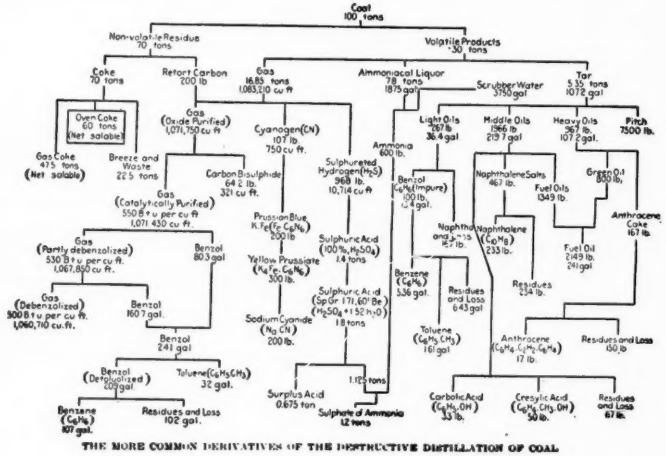
hydrogen into the molecule, and found that in the presence of a proper catalyzer, such as finely divided nickel, various liquid oils and fats would react with hydrogen, and synthetic lard was produced. One of such products is now sold under the name of "Crisco." By this discovery, humanity was set free from its bondage to slaughtered animals for its lard supply, and thousands of tons of artificial shortening materials are now manufactured from cottonseed and other vegetable oils. Useful products are also made from the once despised fish oils, and from other materials which formerly had little commercial value. As the years go by, people will accept the doctrine of the chemist that a product properly made in a factory is just as good as a natural product, no matter what the origin of the raw materials.

A few years ago all wood alcohol, or methanol as it is now called, was made by the destructive distillation of hard woods. A large German chemical firm, since the war, threw into the world's market a considerable quantity of methanol, which called for no wood in its manufacture. They had found that certain hydrocarbon gases, when passed over an appropriate catalyzer under proper conditions, produced methanol so pure that it was better than any wood alcohol that had ever been on the market. Furthermore, as the product is cheaper than wood alcohol manufactured by the distillation of wood, it looks at the present moment as though the wood distillation industry must depend for its profits upon other products. The new process, being so important, has already been introduced in the United States through the efforts of the du Pont Company. More recently the Germans succeeded in synthesizing butanol, which is closely akin to methanol, and is used in tremendous quantities as a solvent in the paint and lacquer trade. Now comes the announcement that by a modification of the same process, they can manufacture ethyl alcohol, and apparently our gin supply for the future is taken care of. It is anybody's guess as to what this latest development will do to the tremendous fermentation industry, which has been built up by the manufacturers of alcohol, both for industrial and beverage purposes.

Numerous other examples of the application of catalysis could be given, but these few will serve to show that as the result of one discovery, old industries may be replaced or seriously modified by new ones.

During the past two years, much prominence has been given to the process developed by Dr. Friederich Bergius of Germany for the direct liquefaction of coal. Bergius found that under proper conditions of temperature and pressure, he could introduce hydrogen into the material at the same time that he dissociated the heavy molecules under the influence of heat. The reactions are somewhat obscure as the material undergoing treatment is of a very complex nature and the hydrogenation reaction is superimposed upon the reactions resulting from thermal decomposition

of the heavier molecules. According to the information which has been made public, Bergius has been able to convert over half of the weight of coal subjected to treatment, to liquid hydrocarbons, working on hundreds of different samples of coal, and in a few instances he has approximated an eighty per cent conversion. Apparently these liquid products are different from the tars which are produced through ordinary distillation of coal, either at high or low temperatures, and yield satisfactory gasoline for internal combustion engines as well as satisfactory lubricating oils. For example, one set of curves published by Dr. Bergius shows that a thousand kilograms of coal produced one hundred and fifty kilos of marketable gasoline, two hundred kilos of an intermediate fraction, sixty kilos of lubricating oil, and eighty kilos of heavy fuel oil. This process has now

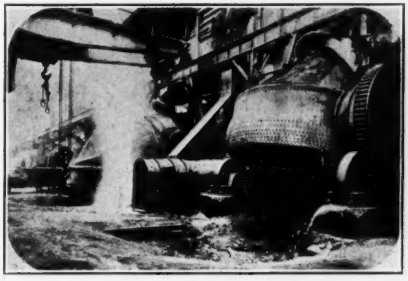


THE MORE COMMON DERIVATIVES OF THE DESTRUCTIVE DISTILLATION OF COAL

reached the commercial stage and one large installation has already been built by the German chemical syndicate to produce fuel oils for the German market. I am told that this plant went into successful operation a few months ago. No data are yet available as to the cost of producing gasoline and lubricating oils from coal by this process, in comparison with the production of these materials from petroleum, and no statement can be made as to the future effect of this important development on the petroleum industry. In this connection, however, it is interesting to remember that, whereas the known oil fields are bound to be exhausted in a relatively short period of time, and new fields must be discovered, the known deposits of coal constitute a reserve for approximately two thousand years at the present rate of consumption. What rôle the Bergius process will play in the future is still unknown, but it is interesting to note that the

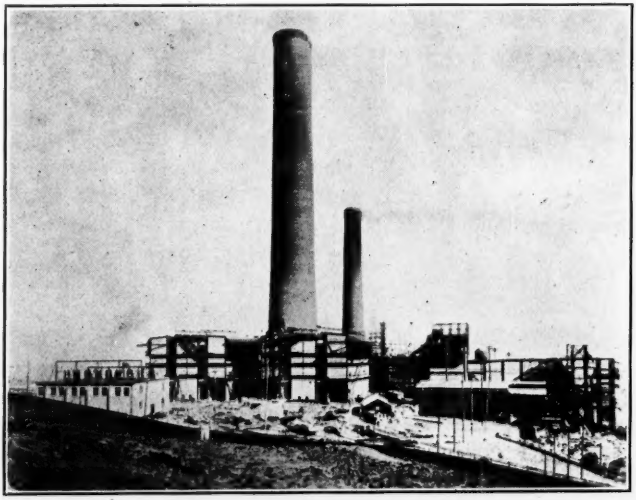
Standard Oil Company has already made arrangements with the German chemical syndicate for the acquisition of the American rights to the process.

One of the spectacular achievements of chemistry was the development of the synthetic dye industry. In 1856 Sir William Perkin treated aniline sulfate with bichromate of potash and obtained a precipitate of aniline black, from which he procured the coloring matter subsequently known as mauve. He lost no time in bringing this substance to the attention of the managers of the Pullar's Dye Works at Perth, and they were so impressed with the product that Perkin took out a patent for his process. With the aid of his father and brother, he erected a small plant at Greenford Green, near Hanover, England, for the manufacture of the newly discovered coloring matter, and by the end of 1857 the works were in operation. That day may therefore be reckoned as that of the foundation of the coal-tar industry, which has since attained such important dimensions. It was in Germany, however, that the aniline dye industry grew to its fullness. Perkin coöperated in the early part of this development work in Germany, and a constantly growing number of dyes were placed upon the market. The Badische Anilin-und-Soda Fabrik spent five million dollars and seventeen years in chemical research before they could make indigo, but by doing so they gained the monopoly of the world's production. One hundred years ago indigo cost as much as $4.00 per pound; in 1914 it was selling at fifteen cents a pound. Even the pauper labor of India could not compete with the German chemists at that price. At the beginning of the present century, Germany was paying more than three million dollars a year for indigo. Fourteen years later, Germany was selling indigo to the amount of twelve million dollars. Besides its cheapness, commercial indigo was preferable because of its uniform quality and greater purity. Vegetable indigo contains eighty per cent of impurities. Commercial indigo is made pure and of any desired strength, so that the dyers can depend upon it. The value of the aniline dye industry is not only measured by the value of its output, for it has produced innumerable colors of the minutest color gradation from one end of the visible spectrum to the other, colors which had never been seen before, but, what is more important, these aniline colors can be made absolutely fast and durable.



Copper Converters at Anaconda.

They look better, wear better and they do not injure the fabric. What is still more important, they have their origin in a dirty waste by-product of the coal industry, and the large plantations which were formerly



Cottrell precipitators at Anaconda.

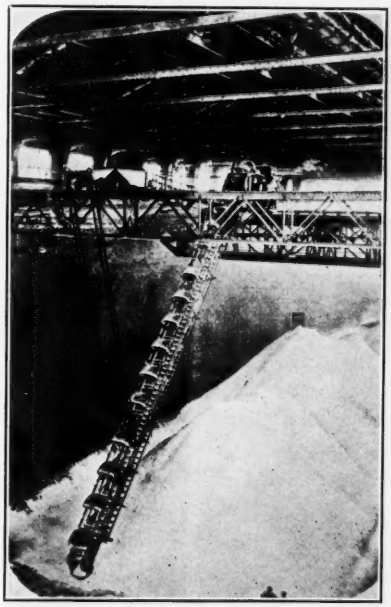
Electrolytic tank house—Raritan Copper Works.

used for the cultivation of plants producing natural dyes are available for the raising of foodstuffs or for recreation.

Recently another very spectacular industry has grown up. The chem-

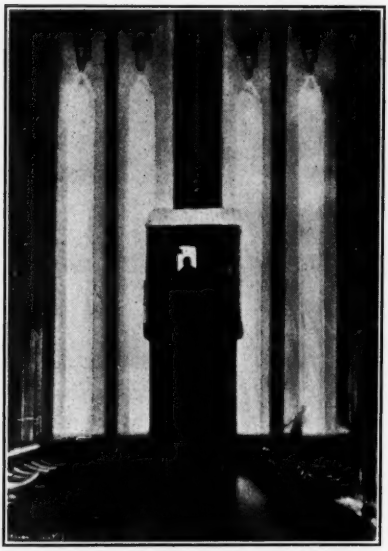
ist found that by nitrating cellulose he obtained an explosive such as gun cotton, but if the nitration was stopped somewhat short, the product was not an explosive, but a nitro-cellulose having most remarkable properties. I am referring here to the manufacture of the so-called pyroxylin products which form the basis of many commercial materials, such as celluloid, photographic films, lacquers, and many other useful materials.

Cellulose can also be treated with caustic soda and then dissolved with carbon bisulfide. This liquid contains the cellulose in solution in the form of cellulose xanthate. On acidifying or heating this solution the cellulose is recovered in a hydrated form. Consequently, if this solution of cellulose is squirted out of tubes through extremely minute holes, into acidulated water, each tiny stream instantly becomes solidified into a silky thread, which may be spun and woven like that ejected from the spineret of the silk worm. What is more important these threads look like silk and, although not as strong as natural silk when wet, have certain superior properties. Since this important discovery was made, a number of processes have been developed for the manufacture of artificial silk and the industry today has taken on tremendous proportions, the production of artificial silk, such as rayon, running into tens of thousands of tons per annum. The poor little silk worm would have had a hard time keeping up with the demands of Dame Fashion had our lady friends set out to wear as much natural silk as they wear today in the form of a chemical factory product. Of course, it was not romantic to think of wearing a beautiful gown, the fibers of which were extruded by a worm, but there was the lure of importation from the orient and the product cost much money, which in itself was a sufficient invitation for our wealthy lady friends to wear the finer silks, but today every shop girl wears her silk stockings and every woman wears her silk lingerie. The cellulose which makes up the major



Interior of a silo of the Oppau Ammonia Works, of the I. G. Farbenindustrie at Ludwigshafen. Storing nitrogenous fertilizers. Holds 250,000 tons total. (A similar one to this exploded a few years ago.)

part of these products grew in the form of trees and after being chewed up in huge hogging machines was subjected to chemical purification, put into chemical solution, squirted through tiny orifices, collected, treated, and dried, spun into threads, woven into fabrics, and dyed with aniline dyes. In 1914 the consumption of artificial silk in the United States amounted to five million pounds, while the consumption of natural silk amounted to thirty million pounds. Ten years later, in 1924, the consumption of artificial silk had risen to forty-two million pounds, while the consumption of natural silk had mounted to forty-eight million pounds. The consumption of artificial silk has now far outstripped the consumption of natural silk, and nearly all of this artificial silk used for domestic consumption is made in the United States. Aside from artificial silks, varnishes, and celluloid, the derivatives of cellulose find use in coatings for airplane wings, in cellophane, which is so extensively used at present as a transparent wrapping for packages, and now they are even producing a colorless, non-breakable, transparent material to be used as a substitute for window glass.

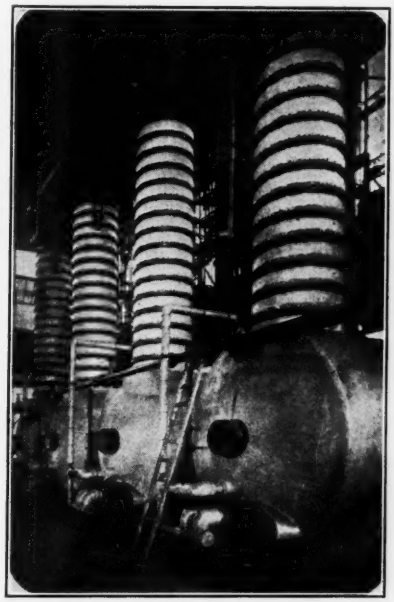


Drawing glass.

These chemical products, as has already been shown, often surpass natural products in many ways. Some have exceptional characteristics, but all of them have uniform properties which make their utilization reliable and definite. A very interesting and useful improvement on natural products is that of the synthetic resins. Baekeland found that he could form a condensation product from a mixture of phenol and formaldehyde, and this product, chemically speaking, is a resin. It has superior properties, however, in that its composition is definite and consequently its characteristics are uniform. This material has found its way onto the market under the name "Bakelite," and it is now used for a thousand different purposes; for example, in the manufacture of cigarette holders, jewelry, telephone instruments, radio dials, insulators, and innumerable other devices and paraphernalia. It has largely supplanted hard rubber as well as natural amber, and is also used in the preparation of numerous lacquers such as formerly were made from natural resins.

Another development along this same line is a condensation product made from casein, the curd of milk. In many metropolitan districts the consumption of cream has become so great that it is difficult to dispose of the skimmed milk. This skimmed milk is now relieved of its casein, and the casein is chemically treated to produce various materials which are sold on the market under such trade names as Galolith, Karolith, etc. This material is also used for the manufacture of cigarette holders, fountain pens, combs, toilet articles, and the like.

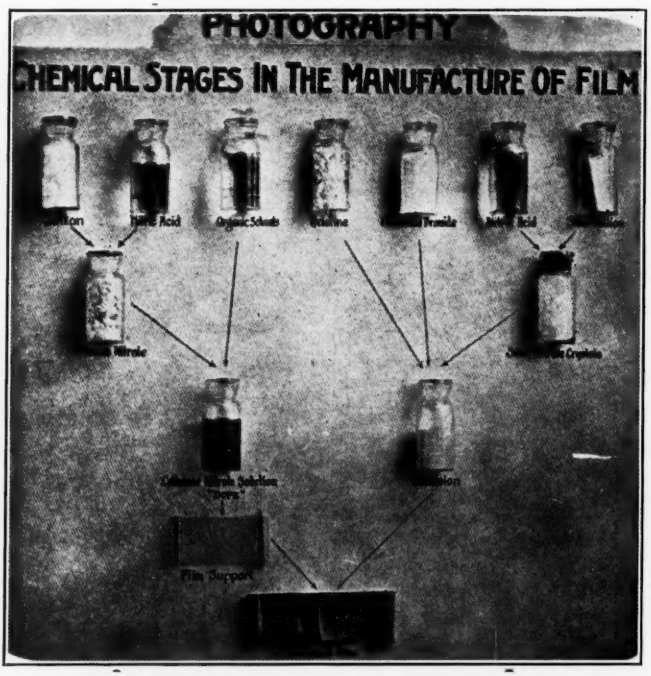
One of the most important results of chemical research has been in the field of metallurgy. It was only a few years ago that the industrial world had available for its needs only the various pure metals and such simple alloys as steel, bronze, and brass. Today there are a thousand alloys having a thousand different properties, and a great many operations which are being performed today would be utterly impossible if these alloys were not available. Take, for instance, the high-speed machine operations which have been made possible only through the development of tungsten steel, vanadium steel, and similar alloys. Or consider the compact high duty power plants such as we have in our automobiles. These would be absolutely impossible of achievement without modern steels, which not only possess great strength, but which are largely immune to the crystallization and cracking which limit the usefulness of ordinary carbon steel. Or consider tough manganese steel, such as is used in armor plate and guns. Leaving the steels, we come to such new products as the hardened aluminum alloys, such as are used in airplanes and dirigibles, both of which would be well-nigh impossible of achievement if it were not for the availability of structural materials which only a few years ago were entirely unknown. Mention should be made of the chrome-iron alloys which are resistant to ordinary corrosion and which now are selling on the market as stainless steel. Mention should also be made of the beautiful copper-



Distillation apparatus for producing benzene, toluene, naphtha, and motor fuel.

nickel alloy, sold under the name of Monel metal, which is rapidly replacing German silver on the one hand and pure nickel and nickel-plated material on the other. No time is available even for a mere recitation of the names of the various alloys which have been produced during the past few years, each one of which finds its own particular use in industry.

Another important metallurgical development has taken place in connection with electroplating. It is now not only possible to electroplate copper, nickel, and silver, but we have such new products on the market



Chemical stages in the manufacture of photographic film.

as chromium plate. The thin film of chromium which is applied not only gives a beautiful surface, but is entirely resistant to corrosion by most of the common chemicals which are encountered in daily life and ordinary industrial operations.

It is unnecessary even to mention the enormous operations which are carried on today for the refining of metals by electrolysis, and this word "electrolysis" brings to mind the huge chemical industries which have been established for the production of chlorine and caustic soda, by the

electrolysis of common salt, the electrolytic manufacture of chlorates, perchlorates, hypochlorites, etc. These operations suggest the large line of products which now are being manufactured in electric furnaces, both of the arc and resistant type; such materials as calcium carbide, carborundum, artificial graphite, ferro-silicon, ferro-chrome, alundum, and a dozen other products. We also have the huge aluminum industry, the manufacture of magnesium metal, calcium, sodium, potassium, etc.

To give a complete review of the present-day chemical industry would be well-nigh impossible. It is only necessary to call attention to the important part which chemistry has played in the development of the petroleum industry, the fertilizer industry, the gas industry, the rubber industry, the soap industry, the paper industry, the cement industry, the ceramic industry, and so on through practically the entire list of present-day industrial operations. The development of photography would have been entirely impossible if it had not been for the work of the chemist. Today the study of photo-chemical reactions is carrying us into entirely new fields, leading toward the direct utilization of radiant energy for the production of useful chemical reactions, such as are now effected by the chlorophyl in the leaves of our growing plants, where the radiant energy from the sun produces a reaction between carbon dioxide and water in the synthesis of cellulose and the myriad other products which are found in the tissues of living plants.

Although this discussion has been limited to a review of new developments, it must not be forgotten that one of the most important and far-reaching contributions of chemistry to industry has been made by the analytical chemists. These men are now to be found in every factory of consequence in all civilized countries, and it is their work which is depended upon for the choice of raw material, the regulation of manufacturing processes and the control of finished products. Without these chemical watch-dogs constantly guarding the factory operations, present-day industry would lose its governor and would end in disaster. These analytical chemists do not play so picturesque a rôle as that enacted by the inventors of revolutionary processes, but we must give them credit for making modern operations possible.

No time is available for even outlining the useful results which have already grown out of the recent studies on the structure of the atom. A few years ago the electron was not even suspected. Today almost every one of us is shooting out electrons in his own home from hot surfaces in highly evacuated tubes, and by doing so is listening to concerts and speeches given at distant points, receiving these messages by virtue of the electromagnetic waves rushing back and forth through the ether. All of this would have been impossible if it had not been for the work of the chemist.

The old dream of the alchemist of transmutation of base metals into gold has certainly come true—although not in the way he contemplated. The second dream of the alchemist is also coming true, at least in part. Although we have given up hope for an elixir of life which can maintain youth everlastingly, we have, through our recent researches in biochemistry, found such specific remedies as adrenalin, insulin, thyroxylin, pituitrin, and too many others to mention. We also have found those mysterious substances, the vitamins, which in infinitesimal quantities will effect the functioning of the human body, and without which human life apparently would vanish from the earth.

Light Color Change Gives New Insight into Structure of Matter. A very recent discovery by a Hindu scientist, Prof. C. V. Raman, that intense light of a single color is partly changed to other colors when it shines on various transparent substances "opens up a wholly new field in the study of molecular structure." This statement was made recently by Prof. R. W. Wood, of the Johns Hopkins University, in announcing that he had completely verified Prof. Raman's discovery in the private laboratory of Alfred L. Loomis, Tuxedo Park, N. Y.

According to Prof. Wood, who has just completed an investigation of the subject with improved apparatus and a more powerful spectroscope than the one employed by Raman, the effect occurs when monochromatic light, which is light of a single color and, unlike white light, is entirely of a single wave-length, shines on transparent substances such as quartz, chloroform, or water. The light that is scattered from the material is mostly of the same color, or wave-length, as that of the light illuminating it. The spectroscope, the instrument that analyzes light, shows, however, that part of the light is changed to wave-lengths a little longer or a little shorter than the source. On the spectrum photographs the result is a heavy line attended on either side by narrower and fainter lines. The fainter groups of lines on one side are the same as those on the other, except that they are reversed, as if reflected in a mirror, the center line being the mirror. Prof. Raman found only a single and very faint line on the high frequency side of the exciting line, but Prof. Wood has found groups of lines on this side almost as strong as the groups on the other in the case of carbon tetrachloride and chloroform.

The importance of the discovery comes from the fact that the difference between the frequencies of the light given off and those of the light which shines on the substance is precisely the same as the frequencies of the absorption bands of the same substance for infra-red light—light which is vibrating too slowly to be seen or to be recorded on the photographic plate without great difficulty. By means of the Raman effect, the physicist can now study these bands of absorption indirectly.

Prof. Wood also pointed out that the effect was one of the most convincing proofs of the quantum theory of light, which supposes that light consists of separate pulses or "quanta," rather than waves, as was formerly supposed. Only by the quantum theory, he thinks, can the effect be explained.

Most of his research was done with crystalline quartz, or such liquids as chloroform and carbon tetrachloride, illuminated with a mercury vapor arc lamp. He is now planning to repeat the work with a spectroscope of 40 feet focus, which will give even more convincing results than those he has now obtained.—*Science Service*

THE CHEMISTRY OF THE RED AND BLUE PIGMENTS OF FLOWERS AND FRUITS. PART II

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The Occurrence and Isolation of the Anthocyanins

Having thus described[1] the very simple relationships existing between pelargonidine, cyanidine, and delphinidine, and digressed briefly to illustrate the methods by which their supposed structures have been so abundantly confirmed by synthesis, it will now be appropriate to consider the natural occurrence of the corresponding anthocyanins in the flowers and fruits. Twenty-one glucosidic compounds of these anthocyanidines have been isolated by the work of Willstätter and Karrer. They have usually been designated by names in which a root indicating the plant source is terminated by the suffix "in" to emphasize the glucosidic character and to distinguish the substance from the corresponding anthocyanidine obtained on hydrolysis. In many cases these root names are derived from the Latin botanical nomenclature.

In the accompanying Table I the names of these twenty-one anthocyanins are so tabulated as to indicate not only the source of the material but also the particular anthocyanidine and the number and kind of carbohydrate molecules with which it is associated. The parenthetical numbers refer to the bibliography at the end of this article. Mixtures of anthocyanins usually occur in any given source but this table lists only those individuals which actually have been isolated. The entries under the heading of indefinite combinations represent cases in which the indicated anthocyanidine was detected but where the exact mode of combination was not fully examined. The presence of the designated organic acids was detected from salvianin, monardein, gentianin, and delphinin: nothing is yet known with regard to the mode of combination of these acids in the original anthocyanin molecule.

The proportion of anthocyanin in the various flowers varies through a wide range. In the first case studied by Willstätter, that of the blue cornflower, the cyanin content is only about 0.75% of the weight of the dried flowers. Since subsequent experience showed that this is the smallest percentage of coloring matter in any of the flowers studied, the glory of the achievement is all the greater. In the more deeply colored blossoms, however, the pigment contents are generally higher. In deep blue-violet cornflowers the cyanin content has risen to 3.6% of the dry weight: in the deep bordeaux shades it may be 13–14%. The cyanin content of the deep red dahlia constitutes 20% of its dry weight and represents the best source of this particular glucoside.

[1] See THIS JOURNAL, 5, 1392–8 (Nov., 1928).

TABLE I

ANTHOCYANIN DERIVATIVES OF THE THREE SIMPLE ANTHOCYANIDINES

Pelargonidine	Cyanidine	Delphinidine
	MONOGLUCOSIDES	
Callistephin—summer aster (14) Pelargonenin—from salvinin of salvia (12)	Asterin—summer aster (14) Chrysanthemin—winter aster (13)	Gentianin—common blue gentian (18). Hydrolysis gives also *p*-hydroxy-cinnamic acid
	MONOGALACTOSIDES	
	Idaein—cranberry (8)	
	DIGLUCOSIDES	
Pelargonin—scarlet pelargonium (9) Pelargonin—orange-red dahlia (11) Pelargonin—red cornflower (11) Salvianint* Salvin Salvinin —red salvia (12) *Hydrolysis gives also malonic acid Monardein—bee-balm (18) Hydrolysis gives Monardin (possibly identical with pelargonin) and *p*-hydroxycinnamic acid Punicin—pomegranate (18)	Cyanin—blue cornflower (6) Cyanin—deep purple cornflower (11) Cyanin—rose (7) Cyanin—deep red dahlia (11) Mekocyanin — double purple-scarlet poppy (17)	Delphinin—larkspur (10) Hydrolysis gives also *p*-hydroxybenzoic acid
	RHAMNOGLUCOSIDES	
	Keracyanin—sweet cherry (15) Prunicyanin—sloe (15) Sambucin—elderberries (18)	Violanin—blue-black pansy (16) Vicin—dark red vetch (18)
	INDEFINITE COMBINATIONS	
Anthocyanidines from radishes (12), scarlet red gladiolas (13)	Anthocyanidines from zinnia, gaillardia, gladiolus, sneeze-weed, tulip, nasturtium, raspberry, red currant, fruit of mountain ash (13, 15)	

The percentage pigment obtained from the dried petals of some other flowers is listed in Table II.

TABLE II

Anthocyanin	Flowers	% Pigment
Delphinin	Wild purple delphinium	1.75
Peonin	Deep violet-red peony	3–3.5
Salvianin	Red salvia	6
Malvin	Wild mallow	6.4
Pelargonin	Scarlet pelargonium	6.6–7.1
Chrysanthemin	Deep red chrysanthemum	7
Callistephin, Asterin	Asters	7.4
Althaein	Hollyhock	11
Petunin	Petunia	15.5
Violanin	Dark blue-black pansy	33

The proportion of violanin in the pansy represents the highest anthocyanin content found during Willstätter's investigations.

The processes for the isolation of the pure anthocyanins from flowers and fruits represent in some respects the most outstanding feature of Willstätter's remarkable work. Quite apart from the obvious difficulties inherent with working with the necessarily large quantities of raw material and solvent and the troublesome solubility relations already mentioned, many other difficult chemical problems had to be solved. For example, it was necessary to devise not only some means of separating the anthocyanins (themselves glucosides) from the accompanying starches, gums, pentosans, and other water-soluble or colloidal material, but also methods of minimizing a tendency on the part of certain of the pigments to change over during treatment to a colorless form. Although these studies of the isolation of anthocyanins are marvels of ingenuity and patience and will be an inspiration to any chemist who will refer to the original papers it is impossible to speak of details here.

For raw materials there could be used either the fresh flowers or commercially dried petals. The objections to the use of fresh flowers arose on one hand from the consequent necessity of carrying out their treatment at fixed times and places and involving the simultaneous collection of a very large number of blossoms, and on the other from the possible complications due to the presence in the fresh flowers of plant enzymes in active form. Substitution of dried for fresh petals obviated both these difficulties but hazarded the loss of anthocyanin through decomposition during the drying. This difficulty proved to be negligible, however, and dried petals were mainly employed. In certain cases, like that of the red poppy, it proved necessary to use the fresh blossoms: Willstätter (Ref. 17) mentions the interesting fact that although the poppy field at the experiment station was picked clean each day, the next morning found a fresh brilliant red surface of new blossoms.

The solvent chosen for the extraction of the pigment from the flower petals or berry skins varied according to the nature of the particular anthocyanin. In the case of the cornflower, water alone sufficed: for the rose, hollyhock, mallow, peony, and huckleberry, a dilute (2%) solution of hydrochloric acid in methyl alcohol was employed: for the larkspur and scarlet pelargonium, dilute alcohol proved suitable: glacial acetic acid was used for the cranberry, grape, salvia, winter and summer aster, petunia, and pansy. Following the preliminary extraction the anthocyanin was precipitated in very impure form by addition of another liquid, usually ether, and the crude precipitate thus obtained subjected to an exhaustive and laborious series of fractional solutions and reprecipitations. These operations ultimately raised the purity of the material to a degree which warranted further treatment by conversion to and crystallization of the picrate or chloride or both. Throughout the procedures Willstätter followed the progress of the purification by colorimetric comparison of the samples with known standards prepared from preliminary experiments.

Since the colors both of red and blue flowers appear to be traceable to the same anthocyanin or at least to a few similarly constituted individuals, the question arises as to how the great variation in effects of shade and tint as well as color itself may be accounted for. The answer appears to be two-fold in character, including on one hand the results attributable to mixtures of anthocyanins one with another or with pigments of other types, and on the other the variation of a given anthocyanin produced by its environment.

In pursuing the first of these causes it may be noted that in a number of instances several different anthocyanins were found in the same source. Thus from the dark purple-red cornflower both cyanin and pelargonin were isolated: in one violet-red variety of *Pelargonium zonale* more cyanin was found than the expected pelargonin. Furthermore, it appears that the characteristic anthocyanin may vary from one variety to another of the same species: for example, although certain deep brownish red dahlias contained as much as 19.4% cyanin and formed the most favorable source of this material, yet other scarlet red varieties contained 4.0–5.6% pelargonin (Ref. 12). Since each anthocyanin possesses a characteristic color under given conditions it is plain that considerable color variation may arise from pigment intermixture. Furthermore, the admixture of yellow pigments with the anthocyanins strongly influences the resultant color. There are three types of these: first, the inert carotinoids, principally carotin, a hydrocarbon ($C_{40}H_{56}$), which is responsible for the color of carrots, and xanthophyll ($C_{10}H_{56}O_2$), one of its oxidation products: second, the glucosidic flavone and flavonol colors; and third, the little known dissolved pigments designated as anthochlors.

As another important source of color variation for cases where pigment

intermixture may not be involved there should be considered the variation in concentration of the particular anthocyanin which is present. Certain of these are able to isomerize to a colorless form and this cause alone may serve to produce color variations in different parts of the same flower. Even apart from this phenomenon, light and deep colored specimens of the same flower often showed pronounced differences in pigment content. To the instances already cited in discussing pigment content may be added another: the bluish red blossoms of one pelargonium contained 0.97% pelargonin on the dried weight, another deep violet-red specimen gave 14.1%. The same difference in concentration of colored pigments may even be exhibited in a single flower: in one large purple dahlia the cyanin content of the inner petals was 23.7%, that of the outer petals 15.1%.

Even more interesting than these predictable concentration effects is the influence of the acid or basic character of the cell fluids, or in other words their pH. It will be recalled that the anthocyanins are amphoteric substances which form salts both with acids and bases. It was concluded by Willstätter that the red forms of anthocyanin represented combinations with acids, the blue forms salt formation with alkalies, and their purple forms an intermediate neutral condition. In the scarlet pelargonium the anthocyanin was found combined with tartaric acid; in the cranberry, citric, benzoic, and gallic acid occur abundantly; the blue cornflower was found to contain its cyanin largely in the form of potassium salt; the violet blossoms of larkspur contained delphinin in neutral condition. Karrer has reasoned that if this be true then blue flowers should yield a higher percentage of ash than red and, noting the meager data, has reported (Ref. 19) the results of analysis of some flower ash. These are reproduced in Table III.

TABLE III

ASH CONTENT OF RED AND BLUE FLOWERS*

	Total ash	SiO_2	K	Na	Ca	Mg	Fe	Al	PO_4
Red blossoms									
Pomegranate	4.29	11.9	18.8	1.1	7.9	1.37	2.78	5.38	6.0
Peony	4.66	2.4	30.5	2.6	7.3	Traces	3.7	1.2	4.2
Pink	6.34	2.77	38.4	0.8	4.0	?	4.4	1.4	12.8
Blue blossoms									
Violet	10.0	5.8	29.7	4.2	2.8	....	5.0	1.8	1.8
Wood mallow	13.8	14.3	42.0	3.9	3.6	3.5	6.2	3.0	6.3
Cornflower	11.1	7.3	17.4	4.8	8.2	Traces	1.2	2.7	7.3
"Black malve"	9.1	11.1	25.4	4.4	9.3	Traces	0.7	6.6	6.2

* Data for individual metals and radicals is given in per cent of total ash.

It is plain that these data support this view.

Bibliography

(6) Willstätter and Everest, "I. The Pigment of the Corn Flower," *Ann.*, **401,** 189–232 (1913).

(7) Willstätter and Nolan, "II. The Pigment of the Rose," *Ann.*, **408,** 1–14 (1914).

(8) Willstätter and Mallison, "III. The Pigment of the Cranberry," *Ann.*, **408,** 15–41 (1914).

(9) Willstätter and Bolton, "IV. The Pigment of the Scarlet Pelargonium," *Ann.*, **408,** 42–61 (1914).

(10) Willstätter and Hieg, "V. An Anthocyan of the Larkspur," *Ann.*, **408,** 61–82 (1914).

(11) Willstätter and Mallison, "X. Variation in the Color of Flowers," *Ann.*, **408,** 147–62 (1914).

(12) Willstätter and Bolton, "XI. The Anthocyan of the Red Salvias," *Ann.*, **412,** 113–36 (1916).

(13) Willstätter and Bolton, "XII. The Anthocyan of the Winter Aster (Chrysanthemum)," *Ann.*, **412,** 137–48 (1916).

(14) Willstätter and Burdick, "XIII. Two Anthocyans of the Summer Aster," *Ann.*, **412,** 149–64 (1916).

(15) Willstätter and Zollinger, "XIV. The Pigments of the Cherry and Sloe," *Ann.*, **412,** 164–78 (1916).

(16) Willstätter and Weil, "XV. The Anthocyan of the Violet Pansy," *Ann.*, **412,** 178–94 (1916).

(17) Willstätter and Weil, "XVIII. The Color of the Poppy. I," *Ann.*, **412,** 231–51 (1916).

(18) Karrer and Widmer, "Investigation of the Plant Coloring Matters. I. The Constitution of Certain Anthocyanidines," *Helv. Chim. Acta*, **10,** 5–33 (1927). "II. Further investigations," *Ibid.*, **10,** 67–86 (1927).

(19) Karrer, Widmer, Helfenstein, Hürliman, Nievergelt, and Monsarrat-Thoms, "IV. The Anthocyans and Anthocyanidines," *Helv. Chim. Acta*, **10,** 729–57 (1927).

Discovers How to Dye Rayon Evenly. Rayon stockings for women or shirts for men can now be dyed more evenly as a result of the discovery of why light stripes sometimes appear even in the best regulated plants. At the recent meeting of the Dye Chemistry Division of the American Chemical Society at Swampscott, Robert W. Jaeger, of Armour and Co., told of his latest researches.

Sometimes in dyeing rayon skeins, one skein will be found to be much brighter than the others, or if the rayon is woven in the piece with some other material, the lighter stripes will appear. The reason for this is that the offending fibers are not perfectly round, as they should be. Though manufacturing methods have been improved, so that this defect is not as common as it used to be, it still occasionally occurs. Microscopic examination of each fiber to see if it is round is impossible, so that methods have been discovered of making the dye stick even to the uneven fibers. The more acid a dye is, the more evenly it dyes.

It has also been found possible to test the dyes without actually applying them to the rayon. This is by measuring how high the color rises in a strip of absorbent paper that is dipped into it. The higher a dye rises, the better it is for the purpose.—*Science Service*

KNOW YOUR FOODS. I. OLEOMARGARINE*

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There is no food, be it raw or manufactured, that passes over the grocer's counter but has its history. The thought that, peculiar to every food, there are some facts not only of historical but of scientific interest as well, which, if translated into the vernacular, will arrest attention, has prompted us to prepare a series of discussions in the hope that we may accomplish what we have expressed in a somewhat mandatory fashion to the end that we may bring to light information not generally known. Perhaps we should admonish you to know your groceries, if you know what we mean.

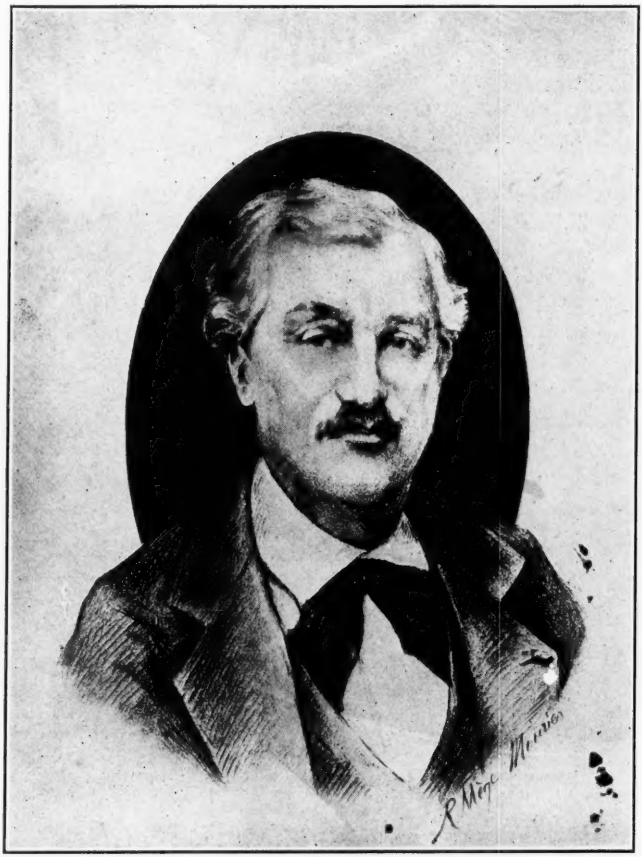
The last war gave rise to a rather descriptive expression in the industries —"war baby." Not many of the infant industries which are created by the exigencies of war survive, yet there is one which, born in a period of national stress, has lived to date some fifty-five years. Its product, oleomargarine, forms the subject of this discussion.

Let us go back and follow through the history of oleomargarine manufacture. A French chemist, Mège Mouries, shortly before the Franco-Prussian War, was conducting experiments in the hope of finding a formula that would give to the world in some palatable form a satisfactory substitute for butter. Napoleon III had offered a prize to stimulate the search for an article of food which would be cheaper and have better keeping qualities than butter, and which could be used as a substitute for butter. The prize for this discovery was awarded in 1870 to Mège Mouries. A somewhat colorful circumstance with which some surround the birth of oleomargarine is that Paris lay under siege by the Germans, its supply of butter was completely shut off, and as a result a prize was offered to any one who would first produce a fat that could be used by the inhabitants of the beleagured city in place of butter. From other sources we learn that its manufacture was suspended with the outbreak of the war in 1870. Be that as it may, however, it is probably not incorrect to say that oleomargarine was conceived during, or at about the time of, a national crisis and therefore, in popular parlance, lays some claim to having been a "war baby."

Mège Mouries sought the solution of the problem in the substitution of an artificial for the natural process as he pictured it taking place in the cow, for he had found by experiment that a cow although restricted in her food to the point where she was losing weight still gave milk containing butter fat. He inferred from this observation that the source of this butter fat was her body fat which by metamorphosis had been secreted as such. From beef he obtained a fat, it is said, "which melted at almost the

* A lecture by radiophone broadcast from Station WHA, University of Wisconsin, February 15, 1928.

exact temperature of butter, possessed a sweet and agreeable taste, and which for most purposes could replace ordinary butter, not, of course, the finest kinds, but which was superior to it in possessing the advantageous peculiarity of keeping for a long time without becoming rancid."[1] He



Courtesy of Inter-Ocean Syndicate, Chicago

R. MÈGE MOURIES

believed it necessary to add in the rendering of the raw fats ferments contained in the gastric juices of a pig, a calf, or a sheep in order to develop those "sweet and agreeable tastes" which he claimed for his product. Later developments in manufacture indicated that this practice was quite

[1] U. S Dept. Agric., *Div. Chem. Bull.*, **13**, 9 (1887).

unnecessary. Letters patent 146,012 for the manufacture of his butter substitute were granted him in the United States on December 30, 1873. His patent possesses at this time only historic value because later developments have rendered practically obsolete his original process of manufacture.

Thus was born, for very innocent reasons, a new industry whose product unfortunately soon entered into unfair competition with genuine butter. "Dutch butter," "butterine," etc., were names given to this article of food but their use was eventually suppressed by law. Because of the fraudulent sale of this food at times special laws were enacted to govern its manufacture and sale. The former was really a disguised blessing, for the manufacturers of modern oleomargarine now point, we believe, with some pride, to the fact that no article of food is so completely supervised and controlled by the Federal Government as oleomargarine, for no ingredient of oleomargarine that contains animal fat escapes this detailed supervision. It begins with the raw material and extends through to the labeling of the finished product.

There is but little difference in the degree of digestibility and the energy of the common edible fats. Although fats have very little if any flavor yet it can be imparted to them to a certain degree. Science has demonstrated how liquid fats can be easily changed into soft or into hard fats. The manufacturer of oleomargarine renders his service to humanity in that he in a sense increases the supply of fatty foods by utilizing the less expensive yet valuable food fats, making them more palatable, and changing them from an inconvenient liquid form to one of a soft or hard consistency.

In making oleomargarine the manufacturer ripens pasteurized milk to that point where it will impart an agreeable flavor to the fats and oils which he prefers to use in his product. The mixture of ripened milk and fats and oils is agitated, chilled, and worked to remove the excess of water from it. It is salted to taste, molded into prints, and packed. Simplicity marks the whole process, which is one that is based on scientific principles. Extreme cleanliness is practised that a product of the desired quality may be obtained.

That oleomargarine as it now leaves the factory is wholesome, pure, and clean, and possesses good food value cannot be questioned. No public health problem seems to be involved in the modern product. It is the only article of food except meat and meat products that is under government inspection and supervision. The Bureau of Animal Industry controls the labeling of it when it contains any animal fat. The Bureau of Internal Revenue controls the labeling of every pound of it regardless of its composition. The Food, Drug and Insecticide Administration has authority to prevent any adulteration or misbranding of it.

Only two kinds of oleomargarine are made in this country. One is made

of animal fats, vegetable fats, salt and milk. The other, which is popularly referred to as "nut oleomargarine," is made of vegetable fats, salt, and milk. Though there is nothing in its composition to suggest the same origin as the type of oleomargarine first developed by Mège Mouries, yet the same name is applied to it because of a statute requirement that butter substitutes of this type be labeled oleomargarine.

The principal raw materials which are at present used in the manufacture of the several types of oleomargarine are oleo oil, oleo stock, oleo stearin, neutral lard, peanut oil, coconut oil, cottonseed oil, milk, butter, and salt. Every manufacturer of oleomargarine uses that combination of these ingredients which best suits his purpose. All of them, it should be said, are never put into any one brand of oleomargarine.

The names of most of the foregoing substances are sufficiently descriptive of themselves to call for no further comment. A few, however, bear description.

Oleo oil, oleo stearin, and oleo stock are prepared from beef fat by successive steps of heating, settling, clarification, crystallization, and pressure. Oleo stock is nothing more than beef fat which has been rendered at a low temperature. It is a mixture of several fatty compounds, some of low melting point and others of higher melting point. This oleo stock is by mechanical means separated into its low melting-point fraction, or olein, and stearin, which has a much higher melting point. The former portion is known as oleo oil.

Neutral lard is rendered from the choicest portions of hog fat, the leaf, by a process very much like that used in the preparation of oleo oil. It gets its name from the fact that it is neutral in flavor, odor, and taste.

Coconut oil is a product of the tropics, the fruit of the palm tree. Peanut and cottonseed oil are largely the products of the temperate zones. Both oils find use as salad oils.

Milk seems to be indispensable in the manufacture of oleomargarine. It is a natural emulsion and an excellent emulsifying agent itself. Before a mixture of fats can be made into a product having the texture, appearance and consistency of oleomargarine, the latter must be emulsified. The addition of milk facilitates this operation. And then, too, milk when "ripened" or sour is the source of the flavor or taste of oleomargarine, a very necessary consideration since the fats which are used in making oleomargarine have been refined to the point where they have no taste or flavor.

In the manufacture of oleomargarine it is desirable that its ingredients be brought together in such a manner that the combination be pleasing in appearance, convenient in texture and consistency, and satisfactory in flavor. To that end pasteurized milk is used. A "starter" is then added to it in order to produce a pure fermentation or souring. To this milk are

then added the fats and oils and the whole thoroughly agitated in churns until a complete emulsion is formed. The latter is then generally drawn off into a spray of ice water that the fats of the emulsion may crystallize. The resulting product has the texture and appearance of freshly churned butter. Water is then worked out of the product and salt added. Since there is a tax of ten cents per pound on artificially colored oleomargarine, very little is colored in the factory. The use of artificial color is discretionary with the consumer. If he wants his oleomargarine colored, he must do it himself.

No discussion on oleomargarine can fail to include some comments on its food value and digestibility, for it is in this direction that much confusion exists. Dr. Charles Harrington of Harvard University, in his book "Practical Hygiene," writes:

> Much has been said concerning its digestibility, and alarmists have gone as far as to claim that it is indigestible and likely to prove a prolific cause of dypsepsia, quite forgetting that the materials from which it is made have held a place in the dietaries of all civilized people since long before butter was promoted from its position as an ointment to that of an article of food. Many comparative studies have been made on this point and the results in general have shown that there is little if any difference. The two are to all intents and purposes exactly alike in point of digestibility.

It was not so very long ago that experiments were made for the purpose of comparing the relative food value of butter and a so-called nut oleomargarine. Dr. Philip B. Hawk, who made these experiments, discusses them from the standpoint of digestibility and energy values as follows:

> In this investigation we took normal men and fed them these fats as they are eaten by the average individual. Then, by means of the most modern of scientific tests, we learned how these foods acted in the human body. In other words, we learned what the stomach and intestine had to say about vegetable margarine and butter. And when the tests were all completed, it was found that the vegetable margarine was just as digestible as butter, that it had as high an energy value and that it was just as completely absorbed from the intestine. In other words, it was equally as satisfactory a food from the above viewpoints as was butter. Such a margarine is also a very economical source of the energy-producing fat which we all need. The digestibility and energy values of this vegetable margarine being fully equivalent to these values possessed by butter, it would seem that the use of it by the public in place of butter is a perfectly sane dietetic policy.[2]

Another very important consideration, viewed in the light of our newer knowledge of nutrition, is the question of the vitamin content of oleomargarine. Dr. Hawk extended his research into these fields also. Briefly summed up, his conclusions with respect to this particular type of vegetable oleomargarine were as follows: an insignificant difference was observed in the "curative" effect produced by good creamery butter and this oleomargarine upon young white rats whose diets had been adequate for

[2] P. B. Hawk, "Old and New Ideas of Diet," Food Research Laboratories, New York, 1926, p. 3.

normal growth in every respect with the exception of vitamin *A*. Likewise the "protective" effect of these foods was studied. One lot of experimental animals was fed upon an adequate diet in which creamery butter furnished the vitamin *A* content, whereas another group was fed on the same diet except that this vegetable oleomargarine replaced the creamery butter. At the end of the test period of some sixty days the "oleomargarine rats" had gained at approximately the same rate as the "butter rats."

Vitamin *D* was also found to be present, but in no greater amount, if equal to it at all, than in butter fat. The discussion, therefore, it would seem, may very properly center around vitamin *A*. This vitamin is present in greater or less degree in some seventy to eighty articles of food. It is abundant in the green leaves of plants, in tomatoes, egg yolk, palm oil, beef fat, fish liver oil, pig's liver oil, kidney, the glandular organs in general, carrots, sweet potatoes, yellow corn, and in milk and its products. In view of this situation, one may ask does not the person who uses an ordinary, well-balanced diet secure enough of this vitamin for satisfactory growth and health? It would appear that he does. The oleomargarine that is made exclusively of vegetable oils, milk, and salt gets its vitamin *A* content from the milk which is always used in its manufacture. And, in fact, milk is used in the manufacture of not only the vegetable type of oleomargarine, but in the animal type as well.

It is only fair to say that there is not unanimity of opinion among those who have made investigations on the vitamin content of the vegetable oleomargarines. But granting that this type may not have been found capable of maintaining satisfactory growth when it was the only source of vitamin *A* in the diet, may it not be proper to ask, in view of the wide distribution of this vitamin in nature, do we ever try to live on oleomargarine alone?

We do not seriously believe that the cow will ever be replaced by the coconut or any other plant product in the "Who's Who" of the diet. The statement of Dr. Hawk that milk always has been and very probably always will be the best food for man's general use, we heartily subscribe to. Milk has no substitute. But as for the fat of milk, evidence supports the view, we believe, that those adults who, for reasons of taste and economy, may prefer oleomargarine, may very well follow their preferences without fear of a nutritional deficiency.

Use of Calcium Chloride. The use of calcium chloride for the laying of dust on roads is meeting with general favor in the Provinces of Ontario and Quebec, Canada, reports Assistant Commercial Attaché Oliver B. North, Ottawa.—*Chem. Markets*, **23**, 214 (Aug., 1928).

THE CORRELATION OF HIGH-SCHOOL CHEMISTRY WITH FIRST-YEAR COLLEGE CHEMISTRY[1]

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The correlation of the courses in chemistry as usually taught in high schools with the first-year college courses in that subject has become a problem of considerable complexity. The professor of chemistry in the college receives from different high schools various students who have had chemistry with a different content and under different teaching methods as well as those who have had no chemistry. This variety in preparation from no chemistry to that which may be considered excellent preparation in that subject from the standpoint of college chemistry has led to dissatisfaction on the part of the college teachers of chemistry who have attempted various means of overcoming the inequalities found in the usual make-up of the introductory college chemistry classes. It has been shown by Koos[2] that there is much similarity between the content of high-school and first-year college courses in chemistry both in classroom texts and in laboratory exercises. It is thought by many that this overlapping should not exist.

Likewise, the American Chemical Society has through its committee on chemical education recognized this problem in its comprehensive investigation of the correlation of high-school chemistry with college chemistry. This society approved the action of its committee in setting forth an outline of minimum essentials for high-school chemistry and for first-year courses in college chemistry[3] with a view to reduce to a minimum any overlapping of the high-school and college syllabi. Furthermore, an objective of this committee was for the colleges to have a different course for those students who have had high-school chemistry.

With this statement of some of the aspects of the problem the following information is given showing the attitude of groups of colleges, both public and private, regarding the recognition of high-school courses in chemistry. This information consists of the answers received from the chemical departments of these institutions in reply to the question: Is the course in general chemistry for freshmen different for those who have had high-school chemistry?

Public Institutions

Of the replies from 68 out of 80 publicly controlled institutions, the

[1] Taken from a coöperative study on "Chemistry and Science in College Entrance and College Graduation Requirements," made under the auspices of the United States Bureau of Education and the American University by the author of this article.

[2] Leonard V. Koos, "The Junior College Movement," pp. 275–286, Ginn & Co., 1925.

[3] THIS JOURNAL, **1**, 87 (1924).

38 that modify freshman chemistry for those who have had high-school chemistry follow; the 30 public institutions that do not modify are not given.

Agricultural and Mechanical College of Texas.—Slightly faster at first. A more rapid start.

Agricultural College of Utah.—Special 15-hour course given for students who have had high-school chemistry. It is more advanced, more theoretical, and includes a beginning in qualitative analysis. General freshman course gives only 10 hours credit.

Alabama College.—Freshman will have general chemistry. Those having had chemistry will have advanced inorganic chemistry treating more thoroughly the theoretical side of the subject.

College of the City of New York.—Based on high-school chemistry and approached from a physico-chemical point of view.

Colorado Agricultural College.—No knowledge of chemistry is presupposed. Classes are sectioned on a basis of ability for the first semester, using Iowa Placement Tests.

Connecticut Agricultural College.—There is a semester course for all students not having had high-school chemistry. There is another course for all students in college.

Hunter College of the City of New York.—Advanced inorganic chemistry for prepared students.

Indiana University.—One group includes freshmen having had high-school chemistry and upper classmen; another group, freshmen who have not had high-school chemistry.

Massachusetts Agricultural College.—Laboratory is synthetic in nature and lectures are grouped around laboratory work. A background of atomic structure and periodic system is used. The beginners follow the usual path.

Miami University.—Laboratory in general chemistry entirely different with many quantitative and synthetic experiments. Classroom work deals with subject matter in more detail.

Montana State College of Agriculture and Mechanic Arts.—Different sections.

North Carolina College for Women.—Yes. No details are given.

Ohio State University.—More advanced course.

Ohio University.—There is an advanced course in inorganic chemistry which may be taken by students who have made *A* or *B* grade in high school and may be elective for any who have had general chemistry.

Purdue University.—More advanced text and laboratory course.

Rhode Island State College.—Different text and instructor.

State College of Washington.—Variation in laboratory experiments.

State University of Iowa.—An attempt is made to bring the high-school

work at the end of the first semester to the point where other students are at the end of the second semester.

State University of Montana.—Less descriptive. More emphasis on physical chemistry—includes first quarter of qualitative analysis.

State University of Nevada.—Twice as much time is allowed for laboratory work to those not presenting high-school chemistry. Lectures are the same but quiz sections separate.

University of Akron.—Separate courses are provided for students intending to major in chemistry but not for those taking chemistry as a minor. One year of high-school chemistry is considered equivalent to only one-half year of college chemistry.

University of Alabama.—Taught from the energy standpoint.

University of Arizona.—Prepared students have more thorough course. The freshman class is divided into two classes on the basis indicated. Those who have had high-school chemistry go faster and more deeply into the subject.

University of Arkansas.—One semester—5 hours against other 2 semesters of 4 hours.

University of the City of Toledo.—Less advanced work for beginners; one more recitation per week.

University of Delaware.—Separate laboratory courses. Lectures the same. Separate quiz sections.

University of Illinois.—One lecture, two quizzes and two laboratory hours per week.

University of Kentucky.—A one-semester course is offered for those who have had high-school chemistry but nearly all students prefer to take the regular freshman course.

University of Maryland.—Entirely different through non-metals.

University of Michigan.—More laboratory for unprepared students.

University of Nebraska.—More advanced—is a 3-credit course instead of 5.

University of North Carolina.—Special laboratory course for those who have had chemistry in high school.

University of Oklahoma.—Use a text dealing only with principles from an elementary physical standpoint.

University of Oregon.—Those having had high-school chemistry will have 3 hours per week instead of 5 hours (in each case one 3-hour period counts 1 hour). The course runs the same hours as the regular 5-hour course and students proving themselves not trained to do extensive work of good quality will be transferred.

University of South Dakota.—Use a more comprehensive text and different laboratory work for those with high-school chemistry credit.

University of Utah.—A general cultural course, largely descriptive and

popular, is given to students not offering high-school chemistry. Chemistry majors, etc., are given a course largely theoretical and mathematical for which either high-school chemistry (or physics) or at least one quarter of the above general course is prerequisite. The two groups are about equal in size. The courses are given by totally different staffs.

University of Washington.—Lectures the same but laboratory assignments are different.

University of Wisconsin.—Yes, if high-school grades are good. Special quiz and laboratory section.

Of the preceding 38 public institutions making special provisions for those entering freshman chemistry, 13 modify laboratory work, 2 of which specify qualitative chemistry and 1 quantitative experiments, 4 give more advanced work, 4 use different texts, 3 emphasize physical chemistry, and 2 require more inorganic chemistry. Some of the other variations are: atomic structure and periodic system, more theoretical, separate sections at first but brought together during the year, less time for prepared students, sectioned according to ability and entirely different throughout non-metals.

Of the 5 out of 38 making special provision for those not having had high-school chemistry, 2 give special laboratory work, 1 gives 5 hours instead of 3, 1 attempts to bring unprepared students up to the standard and 1 offers a special course.

Private Institutions

Of the replies from 83 out of 102 representative privately controlled institutions, the 49 that modify freshman chemistry for those who have had high-school chemistry follow; the 34 private institutions that do not modify are not given.

Amherst College.—Slightly more difficult.

Baker University.—Laboratory work more extensive and intensive.

Barnard College.—Same lectures (2 per week). Different quiz sections and problems. Different laboratory work which is much more difficult—considerable quantitative work and exercises in planning and carrying out experiments.

Bates College.—Different texts. More drill work on problems and equations, etc.

Beloit College.—Laboratory work adjusted to meet needs of students who have had high-school chemistry. More speed in classroom work. A different text is used.

Boston University.—Two courses: *A* for no chemistry is standard course; *B* for high-school chemistry entrants, omits much descriptive matter, has different experiments and includes topics based on high-school chemistry.

Carnegie Institute of Technology.—Less time to elementary work of first semester. Laboratory work more advanced.

Colorado College.—Different sections, instructors, and texts. Students continuing the subject from either section go into the same class in qualitative analysis the next year.

Connecticut College for Women.—First semester—principles of general chemistry. Second semester—elementary qualitative analysis.

Cornell College.—More emphasis on theory.

De Pauw University.—Those who have had no high-school chemistry get extra coaching the first 6 or 8 weeks.

Erlham College.—All students are sectioned on basis of ability. Those having had a high-school course start out in the higher section unless they are lacking in some manner, as shown by placement examination.

George Washington University.—Different courses having one less lecture per week for students having had high-school chemistry; laboratory time the same.

Goucher College.—A one-semester course of 3 semester hours given to those who have had high-school chemistry, covering essentially the same ground as the beginners in 6 semester hours.

Harvard University.—Yes. No details given.

Haverford College.—One half-year course with emphasis on theory, problems, and industrial processes; followed by second half-year of quantitative analysis.

Johns Hopkins University.—Separate laboratory courses and quiz sections for those who had no previous chemistry. Sections move the same for both classes of students.

Knox College.—Class in general chemistry is divided for administrative purposes into two sections. The separation suggested in the question is desirable.

Leland Stanford Junior University.—All high-school students must take a placement examination if they go on in chemistry. Those who fail go along with students who have had no chemistry. Those who pass form an advanced group. The former group takes an extra lecture course of three units.

Lehigh University.—More advanced textbooks and laboratory work.

Maryville College. More theory and problems; more detailed and difficult; and more inclusive all around.

Mount Holyoke College.—Greater emphasis on theory and more extensive.

Northwestern University.—Slightly more advanced treatment with more physical chemistry and problems.

Ohio Western University.—More time is devoted to qualitative and less to general chemistry. After the first year the two sections enter the same class.

Princeton University.—Yes. No details given.[4]

Radcliff College.—Half as long; one-half year instead of one year.

Rice Institute.—Laboratory work more quantitative in character.

Smith College.—High-school chemistry students placed in course or courses by themselves and there is a combined course saving a year for the exceptional students.

Syracuse University.—Different instructors, texts, and laboratory experiments. More principles of chemistry and less description.

Trinity College, District of Columbia.—In laboratory work different methods for preparation of substances and more quantitative experiments assigned. Separate divisions for lecture and recitation.

Trinity College, Hartford, Connecticut.—Have a more advanced text and different laboratory manual.

Tufts College.—Yes. No details given.

Tulane University of Louisiana.—Students who at the end of two weeks' review in general chemistry can successfully pass a quiz on the review take general inorganic and qualitative analysis. Those who do not pass are put in a separate section with a simpler text and less advanced laboratory work. Those who enter the class without any chemistry take a course in college general chemistry.

University of Buffalo.—Those who have had high-school chemistry are permitted to take an examination for exemption from first-year chemistry.

University of Chicago.—Those who have had no high-school chemistry take a 10-hour course; the others a 7-hour course. The textbook for the former is different from that of the latter. The 10-hour course is more descriptive.

University of Notre Dame.—Up to date, only the laboratory work has been different—stressing the quantitative side of the work. Plans are being made to make the classroom work different also.

University of Pittsburgh.—Course for those without high-school chemistry is more elementary, more time devoted to lecture and first half of text is covered more slowly.

University of Rochester.—General discussion of matter is about the same but the advanced class goes much more thoroughly into the general laws of chemistry and their mathematical applications.

University of Southern California.—Beginners have three hours of lecture and a simpler text. Advanced have two hours of lecture. Laboratory of the former is more descriptive and of the latter more quantitative.

Union University.—More advanced.

Vanderbilt University.—We have a course for students requiring more chemistry in their courses, and for those who do not require further chemistry.

[4] For details see THIS JOURNAL, **5**, 851–3 (July, 1928).

Vassar College.—The first part of the first semester is spent in review and in bringing the class together. The class then begins qualitative analysis which is continued throughout the year.

Washburn College.—Main course is the same but special assignments are made to fit individual cases.

Washington and Lee University.—Those presenting entrance units in chemistry take one semester, others two semesters. The former usually take a course in qualitative analysis or a course including elementary inorganic-industrial chemistry the second semester.

Wellesley College.—Those who have had high-school chemistry take one semester of intensive review and more theory and one semester of qualitative analysis (the usual second-year course).

Wesleyan University.—Different sections, text and laboratory, as well as instructor.

Western Reserve University.—More time on principles and less on description.

Whitman College.—Differs in form and order of presentation. More emphasis on theory and a little more advanced.

Yale University.—Different treatment of material provided entrance requirements in chemistry have been passed.

Of the 49 private institutions making special provisions for those entering freshman chemistry, 20 give special laboratory work, 7 of which specify qualitative analysis and 4 quantitative experiments; 8 have different texts and 3 divide according to ability. Some of the variations in these courses are: differences in form and presentation, more advanced treatment of physical chemistry, special courses based on preparation, more time on principles and less description, more theory problems and equations, separate courses, prepared students go more swiftly, one-half year for beginners, different courses, different treatment of materials, and first part of the year spent in bringing classes together. There are 3 institutions which give unprepared students more time.

In conclusion, there appears, therefore, a strong tendency on the part of those in charge of freshman chemistry, in both the public and private institutions, to modify their chemical courses for those who enter them having had high-school chemistry. But there is no marked tendency showing a distinctive method as to how this modification is made with the exception of 13 cases of special laboratory work for the public institutions and 20 for the private ones. The classroom work connected with most of these cases and the remaining 25 of the public institutions and 29 of the private ones is presented through a great variety of methods.

FOREIGN STUDY FELLOWSHIP OPPORTUNITIES

ARCHIE M. PALMER, INSTITUTE OF INTERNATIONAL EDUCATION, NEW YORK CITY

With the inauguration this year of the Austro-American Student Exchange, the foreign study exchange fellowship activities of the Institute of International Education have been extended to include six European countries: Austria, Czechoslovakia, France, Germany, Hungary, and Switzerland. Under these exchanges a limited number of fellowships and scholarships are offered each year to American students who wish to study abroad. These fellowships and scholarships have been established as an international exchange in appreciation of those offered by American colleges and universities to the nationals of the countries concerned.

The fundamental idea behind these foreign study opportunities for American students is to make it possible for America to broaden her horizon and to promote international good will through a better mutual understanding between the United States and foreign countries. That the furtherance of this ideal is being realized is clearly manifest in the activities of those who have returned after an enjoyment of these opportunities, and the increasing breadth of vision and of interest in international affairs on the part of our people generally and of our youth particularly.

Some years ago at a meeting of international societies the late Andrew Carnegie remarked that in time there would be no place in the world for the peace societies which he had founded, but that there would always be need for organizations which would bring different countries together in points of intellectual contact.

Whether one is a foe or a friend of internationalism, whether one believes in a society of nations or thinks that the human race will prosper best when parceled into small, assertive nationalities, one must admit that in the future, as in the past, nations will be stimulated by the contact of one civilization with another. The understanding and appreciation of one's neighbors can be best realized through a comprehension of their culture, of their social life, and of their psychology. In what more effective way can this end be attained than through the interchange of students and teachers, thereby effecting the interpretation through the observing eyes of critical youth?

This year two hundred and eleven graduate students are engaged in advanced study in American colleges and universities and in foreign universities on the exchange fellowships and other foreign study opportunities administered by the Institute of International Education. One hundred and seven of these places are being filled by foreign students and one hundred and four by Americans. This article is concerned with the foreign study opportunities available for American graduate students.

A candidate applying for one of these foreign study fellowships must

(1) be a citizen of the United States or one of its possessions; (2) at the time of making the application be a graduate of a college, university or professional school of recognized standing, or at the time of entering upon the scholarship have met this requirement; (3) be of good moral character and intellectual ability, and of suitable personal qualities; (4) present a certificate or other evidence of good health; (5) possess ability to do independent study and research; and (6) have a practical reading, writing, and speaking knowledge of the language of instruction in the particular country.

These opportunities are open to both men and women. Preference in selection is given to candidates under thirty years of age.

Scholarship and fellowship holders must have sufficient money of their own to cover traveling, vacation, and incidental expenses. Certain steamship lines allow a reduction in steamship rates to the fellows and scholars and in some instances free visas may be secured.

For Study in Austria.—Through arrangements made by the Austro-American Institute of Education in Vienna six fellowships, each covering room and board, as well as tuition in the institutions of higher learning in Vienna, are offered to American students who desire to study in Austria.

A practical reading, writing, and speaking knowledge of German is essential for the proper enjoyment of these opportunities. American Fellows are required to reside in Vienna during the entire academic year, arriving at the time of official opening, about October 15, and remaining for about ten months. The living accommodations are provided in the homes of selected Austrian citizens who are deeply interested in the promotion of cultural relations between Austria and the United States.

Applications for these fellowships must be submitted on or before March 1st.

For Study in Czechoslovakia.—The Czechoslovak Ministry of Education offers, through the American-Czechoslovak Student Exchange, several fellowships of 15,000 Czechoslovak crowns each (equivalent to about $500, which approximately covers room, board, and tuition) to American students who wish to study in Czechoslovakia. These fellowships are available for study at Charles University, the University of Technological Sciences, the Arts Academy, and the Commercial College in Prague, at the Masaryk University and the Institute of Technology in Brno, and the Komensky University in Bratislava.

A practical knowledge of either the Czech or the Slovak language, adequate for understanding lectures delivered in one of these languages, is required of candidates. Preference in selection is given to applicants who have successfully pursued Slavonic studies in an American college or university—primarily to those who intend to become teachers in the subject

of Slavonic languages, or whose major interest is in history or in a scientific field.

American Fellows are required to reside in Prague, in Brno or in Bratislava during the entire academic year from the first of September through June. Scholarship allowances are given only for the time actually spent in Czechoslovakia; payments of the allowance are made by the Czechoslovak Ministry of Education.

Applications for these fellowships must be submitted on or before March 1st.

For Study in France.—The Ministry of Public Instruction and the universities of France offer, through the Franco-American Student Exchange, a number of scholarships covering board, lodging, and tuition, and some providing free tuition only. These scholarships are offered for study at the Universities of Bordeaux, Grenoble, Lyon, Paris, Strasbourg, and Toulouse, at the École Normale Supérieure de Sèvres for women, and at the École Supérieure de la Métallurgie et de l'Industrie des Mines at Nancy for men.

Applicants must have a practical ability to use French books, both in the general subjects and in their own special field, and be able to speak French and understand lectures delivered in French. Applicants are reminded that the standard of work in French universities is very high and to profit by it American students should have already completed a year of graduate work.

Applications for these scholarships must be submitted on or before February 1st.

For Study in Germany.—The German universities, through the Akademischer Austauschdienst, the representative in Germany of the American-German Student Exchange, have established a number of fellowships covering board, lodging, and tuition. This exchange is a movement toward developing international friendship and goodwill by creating a tradition of coöperation and reciprocity between the United States and Germany through the study of the institutions and psychologies of the two countries. These fellowships are available for study at the Universities of Berlin, Bonn, Breslau, Cologne, Frankfurt, Giessen, Göttingen, Griefswald, Halle, Hamburg, Heidelberg, Leipzig, Marburg, Munich, and Tuebingen, and at the various technological institutes.

A practical reading, writing, and speaking knowledge of German is essential to the complete enjoyment of these opportunities. A summer spent in Germany has been found extremely desirable for improving facility in the use of the language.

American Fellows are required to report at the universities to which they are assigned at the time of official opening, about October 15th, and to reside in Germany at least ten months. They may express preference for certain universities, but these preferences must be supported by ade-

quate reasons for the choice. Assignments will be made after consideration of the subjects of study chosen by the candidates.

Applications for these fellowships must be submitted on or before February 15th.

For Study in Hungary.—The Hungarian Ministry of Education offers to American students, through the American-Hungarian Student Exchange, several scholarships covering tuition, lodging in the Nicholas Horthy College for men and in the Elizabeth College for women, and lunch and dinner at one of the students' messes. These scholarships are available at the University of Budapest, the University Faculty of Economic Sciences, the Polytechnic High School, the Veterinary College, and the Music Academy, all in Budapest.

A sufficient knowledge of Hungarian to enable the student to understand lectures is required. Graduates of medical schools who propose to do graduate work and pupils of music may be admitted without a knowledge of Hungarian, provided they have an adequate knowledge of German.

American scholars are required to reside in Budapest during the entire academic year, from early September until the end of June. Scholarship allowances are given for the time actually spent in Budapest.

Applications for these scholarships must be submitted on or before March 15th.

For Study in Switzerland.—The universities of Switzerland offer a number of tuition scholarships to American students, through the Swiss-American Student Exchange. In several instances these scholarships are supplemented by stipends covering board and lodging, or their equivalent, provided in the communities in which the universities are located. These scholarships are available for study at the Universities of Basle, Berne, Freiburg, Geneva, Lausanne, Neuchatel, and Zurich and at the Eidgenössische Technische Hochschule in Zurich and the Handelshochschule in St. Gallen.

Evidence of a good working knowledge of either French or German, dependent upon the language of the institution attended, is required of candidates. A knowledge of both languages is, of course, very desirable.

American scholars are required to report at the universities to which they are assigned at the time of official opening, about October 15th, and to reside in Switzerland until the end of the academic year, which usually ends about the middle of July. During the long vacation periods, especially between terms, March 1st to April 15th, exceptional opportunity is afforded to visit in Switzerland and the surrounding countries of Europe.

Applications for these fellowships must be submitted on or before March 1st.

Additional Opportunities.—In addition to the opportunities mentioned above, the Institute of International Education administers the American Field Service Fellowships for advanced study in French universities and

the Scholarships for the Junior Year Abroad. The Institute also arranges for the placement of a number of American men in "postes d'assistant d'Anglais in French lycées and écoles normales."

Application blanks and further information about these opportunities and about the international exchange fellowships and scholarships may be obtained by addressing the writer at the Institute of International Education, 2 West 45th Street, New York City.

UNITED STATES CIVIL-SERVICE EXAMINATION

The United States Civil-Service Commission announces an open competitive examination for Junior Chemist, $2000.

Applications must be on file with the Civil-Service Commission at Washington, D. C., not later than February 5th.

Competitors will be rated on general chemistry and elementary physics, and the optional subject selected. The optional subjects are advanced inorganic chemistry, analytical chemistry, organic chemistry, and physical chemistry.

The examination is to fill vacancies in the Federal classified service throughout the United States, including the Departmental Service at Washington, D. C.

Full information may be obtained from the United States Civil-Service Commission, Washington, D. C., or from the secretary of the United States Civil-Service Board of Examiners at the post-office or customhouse in any city.

EXHIBIT OF HIGH-SCHOOL STUDENTS' WORK IN CHEMISTRY

An exhibit of students' work in chemistry in high schools is being planned for the spring meeting of the Division of Chemical Education at Columbus, Ohio. All teachers of high-school chemistry are invited to prepare and send in exhibits of their work. Any inquiries regarding the exhibits should be referred to Dr. Wm. McPherson, Ohio State University, Columbus.

Benzol Poisoning in Chemical Laboratories. Benzol poisoning has been found a distinct health hazard in many chemical laboratories as well as in certain manufacturing plants, reports J. J. Bloomfield of the U. S. Public Health Service. In laboratories in which tests are made in connection with rubber, paint, oil, and varnish, benzol is extensively used, not only in the tests but as a solvent for cleaning apparatus and the hands and arms of the workers.

The concentration of more than 100 parts per million of benzol in the workroom air constitutes a health hazard. Substitutes for this substance are recommended to be used as far as possible, particularly for cleaning.

The number of white blood cells is considerably reduced in chronic benzol poisoning, and the nature of the cells also undergoes change. Routine physical examinations of the workers, including examination of the blood, are recommended upon employment, and frequently thereafter, as a means of checking this condition in plants where benzol cannot be dispensed with altogether.—*Science Service*

The Chemistry Student

THE STRUCTURE OF MATTER. IV. IONS AND IONOGENS

OTTO REINMUTH, ASSOCIATE EDITOR

Several times in these pages we have had occasion to mention ions, and last month we published an account of the formulation of the theory of ionization as related by Arrhenius himself.[1] However, we have not as yet discussed ions and ionization in any detail from the standpoint of the structure of matter.

In the first article of this series[2] we noted that combination between atoms may take place in one of two different ways: (1) by the sharing of an electron pair or electron pairs, or (2) by the complete transfer of an electron or electrons from one atom to another, resulting in electrostatic attraction between the two atoms. It is the second type of combination which gives rise to ionization. Atoms which have acquired electrostatic charges by the loss or gain of electrons are called *ions*.[3]

A Brief Retrospect

There is nothing new in the idea that atoms can have electrical charges. Back at the beginning of the nineteenth century when men had but newly learned how to produce electric currents by means of the crudest of batteries, Davy, Berzelius, and other chemists had been quick to seize upon this new force and to note what happened when it was applied to chemical compounds. They observed that when solutions were electrolyzed some elements invariably traveled toward one electrode and that others invariably traveled toward the other. Here at last, they felt, was the answer to the mystery of chemical combination. Some elements, they said, are negatively charged, others are positively charged. Combination is but the result of natural electrostatic attraction between positive and negative elements.

But, unfortunately, the explanation was not so beautifully simple. It was soon found that many compounds were made up of elements which had to be given the same sign. The blow that killed the old "dualistic theory," as it was called, was the discovery that "negative" chlorine could replace "positive" hydrogen in many organic compounds without other-

[1] "Svante Arrhenius and the Theory of Ionization," THIS JOURNAL, **5**, 1486–90 (November, 1928).

[2] THIS JOURNAL, **5**, 1152–63 (September, 1928).

[3] Ions may also be formed in other ways, as we shall presently see.

wise altering the compounds. Perhaps it would be more truthful to say that the theory was knocked out—some life remained in it. While everyone realized that it would not do, no one could help thinking that it held some clue to the truth.

The Modern View

With the acquisition of new knowledge our views have somewhat clarified. We now realize that atoms are not actually positive or negative but only potentially so. More important still, we realize that the ability of any atom to become positive or negative is dependent upon its environment.

In our earlier discussion of the structures of atoms[2] we said that some atoms hold their valence electrons very strongly while others hold theirs but weakly. Some atoms are able to strongly attract electrons to complete their valence shells, while others have little or no attraction for additional electrons. Atoms of these two classes represent the opposite extremes of the range. There are numerous gradations between one extreme and the other. *There is a complete transfer of electrons between two atoms only when one atom is able to hold its electrons but weakly.*

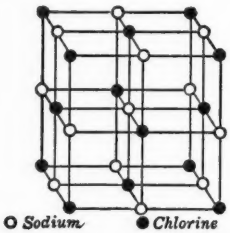


Figure 1.—Arrangement of sodium (white) and chlorine (black) ions in NaCl crystal.

Thus we see that a chlorine atom (which has a very strong attraction for electrons) is able to capture an electron from a sodium atom (which holds its electron but weakly). The resulting compound, sodium chloride, is bound together by electrostatic attraction between the sodium and chlorine *ions*. In fact, x-ray studies have shown that the sodium chloride crystal is a regular piling of alternate sodium and chlorine ions. Each sodium ion is surrounded by six equidistant chlorine ions, and vice versa.[4] (See Figure 1.) When sodium chloride is dissolved in water or some other "ionizing solvent" the ions are able to separate and we say that the compound "ionizes."

If, however, we consider carbon tetrachloride instead of sodium chloride we find quite a different state of affairs. Although carbon does not attract electrons nearly so strongly as chlorine, it holds quite tightly to the ones it already has—much more tightly than does sodium. Hence, when a chlorine atom completes its valence shell by sharing a carbon electron, it has to be content with sharing. It cannot take an electron away from carbon.[5]

[4] Obviously this does not hold true for the surface layers of the crystal.

[5] This phrasing of the case should not mislead any one into ascribing human consciousness or emotions to atoms. The behavior of one atom which acquires an electron from another is quite as impersonal and automatic as that of a large weight which bears down one pan of a balance and, in doing so, raises a smaller weight on the other pan.

The carbon tetrachloride molecule may therefore be represented as in Figure 2*B* in distinction from the sodium chloride atom which must be represented somewhat as in Figure 2*A*. As would be expected, carbon tetrachloride does not ionize.

Figure 2*A* makes plain the reason why sodium and chlorine ions dispersed in water do not act as elementary sodium or chlorine would. Readers of last month's JOURNAL will remember that this mystery was one of the early stumbling blocks to the acceptance of Arrhenius' theory. Arrhenius got around the difficulty by saying that ions were different from atoms in that the ions were charged, whereas atoms are not. If ions are different, he reasoned, they should be expected to behave differently.

That was all right as far as it went, but we are now able to go farther.

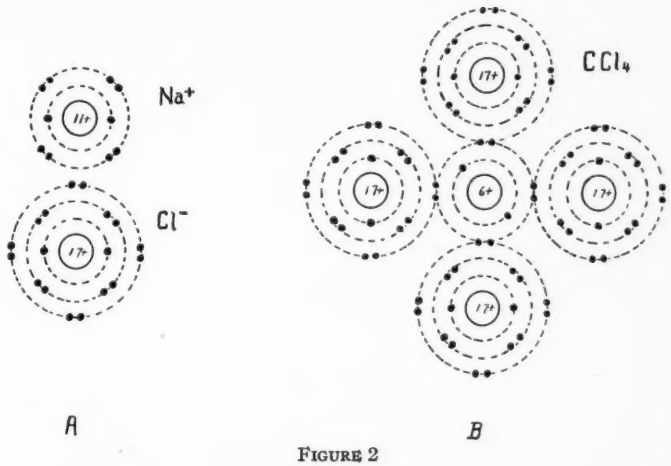


FIGURE 2

The action of sodium on water is due to the fact that the sodium *atoms* give up electrons to the hydrogen of the water. The hydrogen atoms thus formed combine into hydrogen molecules and escape. But a sodium *ion* has no more electrons to give up. It has already been stripped down to its stable shell of eight.

The characteristic activity of elementary chlorine is due to its tendency to acquire electrons. The chloride *ion* has already gained an electron and completed its stable shell of eight. It cannot gain any more.

Electrolysis

We now begin to see why it is that solutions of electrolytes (*i. e.*, of compounds which ionize in solution) can "conduct a current." A glance at

Figure 3 makes the matter plain. Let us suppose that our electrolyte is composed of hydrochloric acid dissolved in water. We have in solution H^+ ions and Cl^- ions. The H^+ ions are attracted to the negative electrode. Perhaps it would be more strictly correct to say that the electrode and the ions are *attracted to each other*, as oppositely charged bodies always are. But the electrode is fixed, so that only the ions move. Now these H^+ ions have come from H atoms which were forced to give up electrons to chlorine atoms merely because the chlorine atoms had a much stronger attraction for electrons. The H^+ ions still attract electrons and will acquire any that are not held too tightly. When these ions arrive at the negative electrode they find electrons not only weakly held but actually "under pressure," so to speak. Each ion immediately acquires an electron and becomes a hydrogen atom. Each pair of hydrogen atoms combines to attain a stable state, thus forming a hydrogen molecule. Hydrogen gas is liberated.

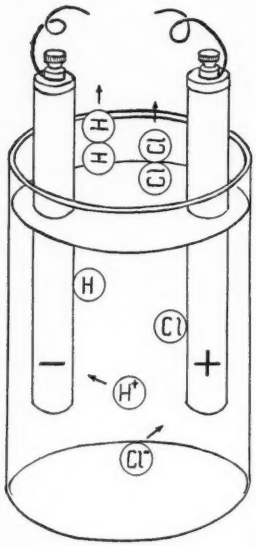


FIGURE 3

In the meantime an opposite state of affairs prevails at the positive electrode. Cl^- ions are attracted and arrive there to find that the electrode has a stronger attraction for electrons than they themselves. The electrons are wrested from the Cl^- ions by the electrode just as they were originally wrested from H atoms by the Cl atoms. Chlorine ions become chlorine atoms and unite with each other to form chlorine molecules. Chlorine gas is liberated.[6]

In view of these facts it becomes apparent that, while electrons enter the solution at one electrode and other electrons leave the solution at the other electrode, no electrons actually travel through the solution from one electrode to the other. Hence, we are speaking rather loosely when we say that the ions in solution "carry the current"—that is, if we define the current as a stream of moving electrons. This mis-statement is, of course, a survival from earlier times when people had no idea what an electric current might be. The best analogy which could then be found was to consider a current flowing through a wire as like a stream of water flowing through a pipe.[7] On

[6] Water is also slightly ionized and a small number of H^+ and OH^- ions arising from water are also discharged. These we shall neglect at this time.

[7] Incidentally the direction of flow which the earlier investigators arbitrarily assigned to the "current" was just opposite to the direction in which we now know the electrons to move.

that basis it was only reasonable to conclude that, if current flowed when an open circuit was closed by inserting the wires in a solution, the solution must act as a connecting link in the pipe line and that the current flowed through the solution.

We now know better. One part of our solution takes on electrons, another gives up electrons. Both parts are used up in the process.

Electroplating

We chose for an illustration of electrolysis a case in which the products of the reaction escape as gases, and in which the electrodes are not attacked.[8] This does not include all the possibilities of electrolysis. The discharged ions may: (*1*) react with each other, as in the case discussed; (*2*) react with the solvent, usually water; (*3*) attack the electrode; or (*4*) attach themselves to the electrode.

Case (*2*) describes what happens when water is acidified with sulfuric acid and electrolyzed to produce hydrogen and oxygen, and explains why the electrolysis of a sodium salt results in the escape of hydrogen and the formation of NaOH around the negative electrode.[9] In order to kill two birds with one stone let us consider what happens when a solution of sodium sulfate is electrolyzed, using platinum electrodes.

The sodium ions travel to the negative electrode and receive one electron apiece, thus becoming sodium atoms. Elementary sodium reacts immediately with the water of the solution, releasing hydrogen and forming sodium hydroxide. At the positive electrode SO_4^- ions give up two electrons apiece and become uncharged SO_4 radicals. Now the SO_4 radical cannot exist as such and it is probable that it immediately breaks down into SO_3 and O. Sulfur trioxide reacts with water to form sulfuric acid, and oxygen atoms combine with each other to form oxygen molecules and escape.

Unless special precautions are taken to prevent the mixing of the solutions surrounding the two electrodes, the sulfuric acid formed at the positive pole and the sodium hydroxide formed at the negative pole mingle and react to re-form sodium sulfate and water. The net result is that the water of the solution is decomposed into hydrogen and oxygen and the sodium sulfate remains.

Cases (*3*) and (*4*) may be illustrated by one example. Let us suppose that a silver nitrate solution is electrolyzed between silver electrodes.

[8] Electrodes which remain unattacked may be obtained in actual practice by the use of platinum or of carbon.

[9] Teachers who object to the assumption of secondary products of electrolysis in this connection are referred to Sir James Walker's "Introduction to Physical Chemistry," ninth edition, The Macmillan Company, New York, **1922,** pp. 368–70. Such objections are there answered in detail.

The Ag^+ ions move to the negative electrode, and receive electrons but instead of breaking away to combine with other silver atoms so formed (in the manner of hydrogen) they attach themselves to other silver atoms which already form a part of the electrode.[10] At the positive silver electrode NO_3^- ions are meanwhile giving up electrons and becoming uncharged NO_3 radicals. The NO_3 radicals react with the silver of the electrode to form more silver nitrate.[11] The net result of the operation of this electrolytic cell is the transfer of silver from one electrode to the other. This is the process employed in the electrolytic refining of copper (copper sulfate being the electrolyte employed). When the negative electrode is made of some metal other than the one with which it is coated in this manner, the operation is known as plating.

The Electromotive Series

We have repeatedly made mention of the fact that some atoms attract and hold electrons more strongly than other atoms. Let us consider in a little more detail just why this should be.

Recalling to mind our elementary physics we remember not only that oppositely charged bodies attract each other, but that the attraction is proportional to the magnitude of the charges. Upon this basis we should expect that atoms with high positive nuclear charges would attract electrons more strongly than atoms with small positive nuclear charges. But in so reasoning we have been taking it for granted that the linear distance between the charges remains constant. This is not true in the case of atomic nuclei and valence electrons. Since electrons are arranged in layers or shells about the nucleus it follows that the valence shells of atoms with large central positive charges are farther removed from those positive charges than are the valence shells of atoms with low nuclear charges. Hence we have two factors operating oppositely, for our elementary physics has also told us that the attraction between charges is inversely proportional to the square of the distance between them.

In addition there are still other complications. The valence shells of large atoms are not only at comparatively great distances from the nuclei, but they are probably somewhat "screened" from the attractive forces of the nuclei by intermediate layers of electrons. Finally, we also find that the state of completion of the valence shell has an influence on the power of the atom to attract electrons. It seems that the nearer the shell is to the completion of the stable octet of electrons, the more attraction the

[10] The silver atoms also attach themselves to the electrode if it is made of copper or any one of a number of other metals.

[11] Some will prefer to consider this reaction as occurring in stages: the decomposition of the NO_3 radical, the oxidation of Ag to AgO, and the subsequent formation of $AgNO_3$. In either case the final result is the same.

atom has for electrons. Obviously, it is difficult to arrive at any simple mathematical means of placing the atoms in the order of their respective degrees of attraction for electrons.[12] However, it has been possible, by experimental means to construct such a series for some of the elements, and this series, known as the "electromotive series," has proved to be of great practical use. (See Table I.)

TABLE I
ELECTROMOTIVE SERIES

Cs
Li
K
Ba
Na
Ca
Mg
Al
Zn
Fe(Fe^{2+})
Ni(Ni^{2+})
Sn(Sn^{2+})
Pb(Pb^{2+})
Fe(Fe^{3+})
H
Bi(Bi^{3+})
As(As^{3+})
Cu(Cu^{2+})
O(OH^-)
Cu(Cu^+)
I(I^-)
Hg(Hg_2^{2+})
Ag
Pb(Pb^{4+})
Hg(Hg^{2+})
Br(Br^-)
Au(Au^{3+})
Cl(Cl^-)
Au(Au^+)
F(F^-)

In Table I the elements are arranged from top to bottom in the order of increasing attraction for electrons. One would therefore expect that elements low in the table would succeed in capturing electrons whenever there is competition for electrons between themselves and elements higher in the table. As a matter of experimental fact we find that hydrogen ions are able to capture electrons from atoms of any of the elements which stand above hydrogen in the table and that they are unable to capture electrons from atoms of elements lower in the table. This fact is usually expressed by saying that metals above hydrogen in the table can liberate hydrogen from acids whereas metals below hydrogen cannot.[13]

When zinc and hydrochloric acid, for instance, react it is said that zinc liberates hydrogen from the acid. What actually happens is that hydrogen ions in solution take electrons from zinc atoms. The zinc atoms thereby become ions and pass into solution. The hydrogen ions become atoms, combine with other hydrogen atoms to form molecules, and escape. If we are justified in thinking of any reactant as taking the initiative in the reaction, the hydrogen ion is the initiator.

A similar example involving other elements is seen in the coating of a knife-blade with copper when it is immersed in a copper sulfate solution. Copper ions capture electrons from iron atoms. The iron atoms become ions and go into solution. The copper ions become atoms and deposit on the knife blade.

[12] Dr. Langmuir, who pointed out the factors influencing the degree of attraction for electrons, was content to state the case qualitatively. Dr. Cartledge has attempted with some success to arrive at a quantitative evaluation and has devised a periodic system of the ions which takes account of "ionic potentials." Advanced students and teachers are recommended to examine "Studies on the Periodic System. I. The Ionic Potential as a Periodic Function," *J. Amer. Chem. Soc.*, **50**, 2855–63 (Nov., 1928).

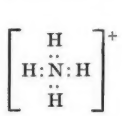
[13] There are some exceptions to this statement, but they are due to secondary factors which are readily recognized and they do not invalidate the basic principle expressed.

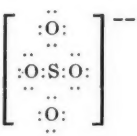
Ions Other than Charged Atoms

At the beginning of this article we stated that atoms which have acquired charges by gaining or losing electrons are known as ions. That was merely a statement of fact—not a definition. Ions may be produced in other ways.

Last month[14] we considered the interesting case of the ammonium ion. Here a neutral molecule becomes a positive ion by acquiring a positive charge—*i. e.*, by combining with a proton or hydrogen ion.

The sulfate ion may be represented as similar to the ammonium ion, except that, whereas the latter has one excess positive charge, the former has two excess negative charges.





It is evident that such ions arise out of the tendency of atoms to complete their stable groups of electrons. So strong is the tendency that the resulting groupings are remarkably stable even though they are not electrically neutral. Such ions go through many chemical reactions as though they were single atoms rather than aggregations.

We see therefore that an ion may be a proton (H^+), a charged atom, or a charged group of atoms. A lone electron may also constitute an ion. Sodium dissolved in liquid ammonia ionizes as follows:

$$Na \rightleftharpoons Na^+ + \epsilon^-$$

[14] THIS JOURNAL, **5**, 1473–9 (Nov., 1928).

Compressed Air Aids Shade Trees. Compressed air forced in among the roots of large trees that have been transplanted has been found to be of assistance in causing the tree to recover quickly from the disturbance, as in most planting operations the dirt is thrown back into the soil with so much water that it puddles and prevents the roots from getting needed air from the soil.

The same compressed air treatment is stimulating to trees in lawns, where, apparently, the roots of the densely matted grasses forming the sod sometimes release so much carbon dioxide in respiration that the supply of oxygen in the soil is dangerously reduced. The method can also be applied to street trees which suffer greatly from leaking gas mains and from soil compactness due to paving, or to park trees where the soil is badly trampled by crowds of recreationists.

The air is supplied by any air pump such as those used to fill air tanks at service stations or those used for pneumatic drills and hammers, and is forced into the soil through a deep nozzle. Many dying shade and ornamental trees can be encouraged to make new growth and so take a new lease upon life by a treatment of compressed air.—*Science Service*

HYDROGEN-ION CONCENTRATION

R. HARMAN ASHLEY, TUFTS COLLEGE, BOSTON, MASSACHUSETTS

As this topic involves the designation of magnitudes by the system of powers of ten, a few remarks about this way of designating magnitudes may be pertinent.

Notation by Powers of Ten

In this system the units place is taken as the center of symmetry and all numbers are written in this place followed by ten raised to the appropriate power. In the units place the power of ten is zero, that is, $1 = 10^0$, consequently a magnitude between 1 and up to 10 need not be followed by the ten factor; all other magnitudes will call for a ten factor. In this system, instead of writing

88	write 8.8×10^1
4900	write 4.9×10^3
0.0000725	write 7.25×10^{-5}
968.45	write 9.6845×10^2
0.326	write 3.26×10^{-1}

To transform a magnitude written in the system of notation by powers of ten to the usual system, reverse the above process. Thus, to convert 8.425×10^2 into the ordinary notation, the factor 10^2 becomes 100, hence 8.425×10^2 becomes $8.425 \times 100 = 842.5$. For example:

9.62×10^5 becomes	962000
8.79×10^{-1} becomes	0.879
4.53×10^{-5} becomes	0.0000453

The conversion of numbers into the system of notation by powers of ten and vice versa will be easily remembered by those accustomed to logarithms. When a number is written in the usual notation, in order to convert it into the system of notation by powers of ten, write the number with the first significant figure in the units place, followed by the decimal point and the other significant figures. Multiply this by the appropriate power of ten. When the original number was greater than 1, and less than 10, no power of ten is called for; if greater than 10, the power of ten to employ is positive and is the same as the characteristic of the logarithm of the number. When the original number is less than 1, the power of ten to employ is negative and is the same as the characteristic of the logarithm of the number.

Equilibrium

An acid may be typified as HA in which H is the ionizable hydrogen and A the acid radical. On going into solution ionization takes place according to the equation:

$$HA \rightleftharpoons H^+ + A^- \qquad (1)$$

Applying the mass law to this equilibrium:

$$\frac{[H^+] \times [A^-]}{[HA]} = K_a \qquad (2)$$

A few remarks about the above expression: a symbol, formula, or radical enclosed in a square bracket has a special significance. A symbol or formula written without the bracket stands for a definite weight of substance, equal numerically to the atomic or molecular weights of the substances designated. When a symbol or formula is enclosed in a square bracket it has the added significance of *concentration*. Thus, the symbol H^+ represents 1.008 parts by weight of hydrogen ions, while $[H^+]$ is used to represent the *concentration* of hydrogen ions. As the unit of weight in chemical measurement is the gram and the unit of volume is the liter, then $[H^+]$ represents the number of gram molecules of hydrogen *ions* in each liter of the solution. The molar system of expressing concentration is based on these units, a unit molar solution being one which contains one gram molecular weight of the dissolved substance disseminated in a liter of the solution. Any given solution may be a multiple or sub-multiple of the molar unit. For example, the formula of acetic acid being $H{\cdot}C_2H_3O_2$, the molecular weight is 60.042, hence if this weight of acetic acid in grams (one gram molecular weight) is dissolved or present in a liter of solution, the solution is of molar concentration. On going into solution, only a small portion of the molecules of acetic acid break up into ions. In a molar solution, out of every ten thousand molecules of the original acetic acid molecules, only 42 are in the ionic condition. Forty-two parts in 10,000 may be represented as 0.0042 or 4.2×10^{-3}. If the acid of equation (1) is molar acetic acid then the numerical value of $[H^+]$ in this expression is $[H^+] = 4.2 \times 10^{-3}$.

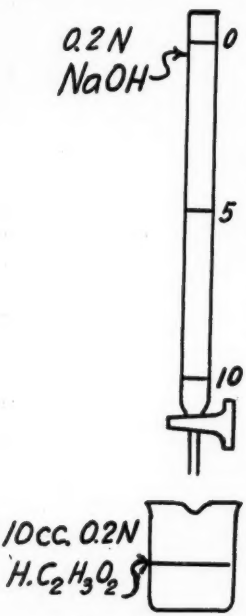


FIGURE 1

The term K_a has a special significance: it is a constant. No matter how the values of $[H^+]$, $[A^-]$ or $[HA]$ may be changed, the equilibrium will adjust itself either by an increase or decrease of ionization until the value of K_a is regained. While the concentration factors on the left side of the equation may be varied, no variation of K_a is possible, it is a constant of

nature. The numerical value of K_a changes with the acid under consideration and with the temperature, but in general is independent of the dilution. As it is conventional to write the equilibrium equation of an electrolyte with the concentration of the ions in the numerator, a tabulation of the values of K_a will be a measure of the strength of the acids tabulated. As the strength of an acid depends on the *concentration* of the hydrogen ions it follows that the larger the value of K_a, the stronger is the acid. Strong electrolytes, in this case strong acids, do not give a constant value for K_a for all dilutions and are not included in this discussion. To calculate the value for K_a for acetic acid: the concentration of the hydrogen ions is $[H^+] = 4.2 \times 10^{-3}$, and the concentration of the acetate ions is the same, for each acetic acid molecule on ionizing produces one hydrogen ion and one acetate ion. The concentration of the unionized acetic acid is $1.000 - 0.0042 = 0.9958 = 9.958 \times 10^{-1}$. Substituting these values in equation (2) gives

$$\frac{(4.2 \times 10^{-3}) \times (4.2 \times 10^{-3})}{9.958 \times 10^{-1}} = 1.8 \times 10^{-5}$$

from which $K_a = 1.8 \times 10^{-5}$ for acetic acid. These constants are called dissociation or ionization constants.

The ionization of a base may be represented:

$$BOH \rightleftharpoons B^+ + OH^-$$

the equilibrium expression of which comes to

$$\frac{[B^+] \times [OH^-]}{[BOH]} = K_b \qquad (3)$$

The value of K_b gives information about the degree of ionization of the base at different dilutions and the same remarks apply to K_b as were given with K_a.

Following are a few dissociation constants for acids and bases:

Class	Compound	K_a
Strong acid	Hydrochloric acid	Not well defined
Moderately strong acid	Oxalic acid	1.1×10^{-1}
Weak acid	Acetic acid	1.8×10^{-5}
Very weak acid	Boric acid	6.5×10^{-10}

BASES

Class	Compound	K_b
Strong base	Sodium hydroxide	Not well defined
Weak base	Ammonium hydroxide	1.8×10^{-5}
Very weak base	Aniline	4.6×10^{-10}

Soluble salts are ionized and a constant K_s might be worked out in the same manner as for acids and bases. It may be said roughly that salts are generally highly ionized, those of the weak acids and weak bases included.

Dissociation of Water

Water is slightly dissociated into H^+ and OH^- according to the equilibrium:

$$HOH \rightleftharpoons H^+ + OH^-$$

The equilibrium expression is

$$\frac{[H^+] \times [OH^-]}{[H_2O]} = K_1 \qquad (4)$$

As the dissociation of water is so slight the concentration of the undissociated molecules of water may be taken as a constant: call it K_2; then

$$\frac{[H^+] \times [OH^-]}{K_2} = K_1$$

and

$$[H^+] \times [OH^-] = K_1 \times K_2 = K_w \qquad (5)$$

Values of the constant K_w determined by various methods agree very well, the accepted value being, $K_w = 10^{-14}$.

From the above it is apparent that the concentration of the H^+ ions varies inversely with the concentration of the OH^- ions; hence, in every water solution of an acid, a base or a salt, both H^+ ions and OH^- are always present. Take, for example, a solution of a base which is $0.01N$* (normal) in respect to OH^- ions. From (5) the concentration of the H^+ ions is

$$[H^+] = \frac{K_w}{[OH^-]} \qquad (6)$$

Knowing the concentration of OH^- ion to be $0.01N$, then $[OH^-] = 10^{-2}$ and substituting in (6) gives

$$[H^+] = \frac{10^{-14}}{10^{-2}} = 10^{-12}.$$

From the above it is apparent that the concentration of a base or an acid may be expressed in terms of the concentration of H^+ ions.

The Ionization of an Acid

The equilibrium equation (2) being

* A *normal* solution is one which contains one gram *equivalent* of replaceable hydrogen ions, or that weight of element, or radical, which will react with or replace one gram equivalent of hydrogen ions, in a liter of solution. When we are dealing with H^+ or OH^- ions, we are dealing with monovalent substances, and in such cases the normal solution and molar solution are of the same concentration.

$$\frac{[H^+] \times [A^-]}{[HA]} = K_a \tag{2}$$

may be rearranged to

$$\frac{[HA]}{[H^+] \times [A^-]} = \frac{1}{K_a}$$

Multiplying both sides by $\frac{[A^-]}{[HA]}$ gives

$$\frac{1}{[H^+]} = \frac{1}{K_a} \times \frac{[A^-]}{[HA]}$$

Taking logarithms gives

$$\log \frac{1}{[H^+]} = \log \frac{1}{K_a} + \log \frac{[A^-]}{[HA]} \tag{7}$$

The term, $\log \frac{1}{[H^+]}$, has a special significance for this discussion and is designated pH. That is,

$$pH = \log \frac{1}{[H^+]} \tag{8}$$

In words, pH is the logarithm of the reciprocal of the concentration of the hydrogen ions. The term $[H^+]$ is often written C_H.

The Titration of Acetic Acid with Sodium Hydroxide

Ordinary analytical titrations of acids and bases take account only of the end point or point of equivalence, the changes in concentration of the acid or base not being accounted for during the course of the titration. Suppose 10 cc. of $0.2N$ acetic acid is titrated with $0.2N$ sodium hydroxide. The alkali is in the buret and the acid in the beaker, the changes of $[H^+]$ of the latter will be followed. Acetic acid is a weak monobasic acid, the dissociation constant for which is $K_a = 1.82 \times 10^{-5}$. This shows a slightly dissociated acid; in $0.2N$ solution only 0.9% of the acetic acid molecules being ionized, the remainder being in molecular form. As sodium hydroxide is added from the buret, sodium acetate is formed, the latter being highly dissociated into ions. This sodium acetate is the source of most of the acetate ions, $C_2H_3O_2^-$ corresponding to the A^- ions of equation (1). This being the fact, the factor $\frac{[A^-]}{[HA]}$ in equation (7) approximates $\frac{[Salt]}{[Acid]}$. Substituting this in equation (7) gives

$$\log \frac{1}{[H^+]} = pH = \log \frac{1}{K_a} + \log \frac{[Salt]}{[Acid]} \tag{9}$$

To give in detail the method by which the change in pH varies with

successive additions of the sodium hydroxide to the acetic acid would expand this article beyond the limit of its intention. The calculation is made by use of equation (9), all the factors of which are easily approximated. When calculated or plotted a curve given in Figure 2 results.

Two facts are to be noted concerning this curve. (1) The addition of small amounts of sodium hydroxide at the beginning and at the end of the titration produce very large changes in the pH, and (2) in the middle portion of the curve, the addition of considerable sodium hydroxide changes the pH but slightly. In this middle portion of the curve when the acetic acid is half neutralized, the solution exhibits "buffer" action; that is, it

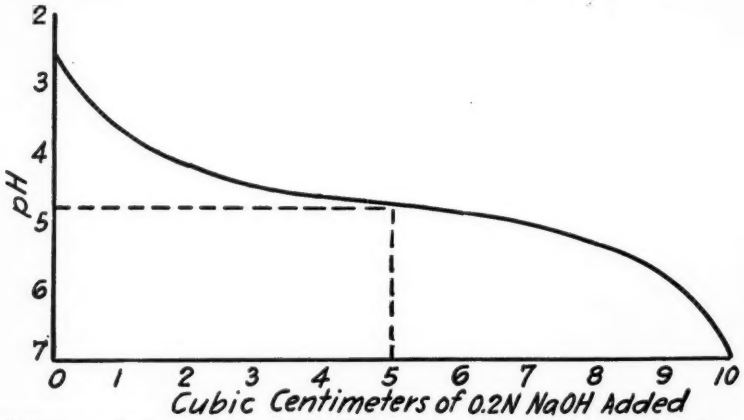


FIGURE 2.—Curve showing variation of pH with successive additions of NaOH to $H{\cdot}C_2H_3O_2$.

changes but slightly in its pH on the addition of acids or bases. More will be said about this "buffer" action later.

The pH Scale

The normal and molar system of expressing the concentration of acids and bases does not distinguish between the quantity of H^+ ions actually present at a given dilution and the potential quantity of H^+ ions. The pH scale does this and indicates what might be termed the intensity factor; that is, it is a measure of the actual concentration of the H^+ ions present in the solution. Recollecting that $pH = \log \frac{1}{[H^+]}$, it is to be noted that the values are always positive and the higher the concentration of the H^+ ions, the smaller is the value of pH, while on the contrary, the lower the concentration of the H^+ ions, the higher is the value of the pH.

There are other advantages. As a change of one unit of pH involves a

ten-fold change in the concentration of the H^+ ions, the system is more compact. Further, in the actual determination of the pH of a solution as carried out by electrical measurements, many of the relationships are proportional to the logarithm of the hydrogen-ion concentration and are not proportional to the $[H^+]$ concentration.

The pH Value of Pure Water

The value of K_w for pure water is 10^{-14}, that is,

$$[H^+] \times [OH^-] = K_w = 10^{-14}. \tag{5}$$

For every H^+ ion an OH^- ion is simultaneously formed, then as $[H^+] = [OH^-]$, the expression becomes

$$[H^+]^2 = 10^{-14}$$

and

$$[H^+] = \sqrt[2]{10^{-14}} = 10^{-7}$$

Hence, the pH of pure water is 7. It is then seen that a neutral solution has a pH of 7, and an acid solution will show a pH *less* than 7; the greater the acidity the smaller will be the value of pH. So also an alkaline solution will have a pH value *greater* than 7; the larger the departure upward above 7, the greater the alkalinity.

Calculating the Value of pH

Suppose a $0.10N$ solution of acetic acid is ionized to the extent of 1.3%. This would mean that it contains $\frac{0.013}{10} = 0.0013$ gram molecular weights (moles) of H^+ ions per liter or it is $0.0013N$ in respect to H^+ ions. The pH of the solution is

$$\text{pH} = \log \frac{1}{1.3 \times 10^{-3}}.$$

To calculate the numerical value of pH:

$$\text{pH} = \log 1 - \log 1.3 \times 10^{-3}$$

Subtracting,

$$\log 1 = \underline{0.0000}$$
$$\log 1.3 \times 10^{-3} = \overline{3.1139}$$
$$\overline{2.8861}$$

from which it is seen that a $0.10N$ acetic acid solutionhas a pH = 2.89 to the nearest three figures. Seeing $\text{pH} = \log \frac{1}{C_H} = -\log C_H$, another way of defining the term pH is to say that it is minus the logarithm of the hydrogen-ion concentration. An alternative method of calculating the pH

corresponding to a certain $[H^+]$ is to note that a solution which is $0.0013N$ in respect to H^+ ions might be expressed as being $\frac{N}{769}$. The logarithm of 769 is 2.89, which is the pH corresponding to this normality.

It is conventional to express $[H^+]$ so that the tens factor shall show an integral exponent. Thus, $[H^+] = 10^{-11.27}$ would be converted into the form $a \times 10^b$ in which b is an integer. Thus to find the $[H^+]$, or C_H, corresponding to pH = 11.27: the problem is to find the unit factor for a such that b is an integer. In the problem given:

$$[H^+] = 10^{-11.27}$$
$$= 10^{-12 + 0.73}$$
$$= 10^{0.73} \times 10^{-12}$$

The antilogarithm of 0.73 is 5.37, then

$$[H^+] = 5.37 \times 10^{-12}$$

Buffer Action

Although *pure* water would show a pH of 7, distilled water prepared under ordinary conditions will show a pH of considerably less than 7. This is due to several causes; notably, absorption of carbon dioxide forming carbonic acid and also the solvent action of water on the glass of the container. Water containing no dissolved salts is very sensitive to the addition of acids or bases. If to a liter of pure water showing a pH of 7, one cubic centimeter of $0.01N$ HCl is added, the resulting solution would show a pH of 5. On the other hand, if to a liter of beef infusion the same quantity of acid is added, the change in pH is hardly perceptible. The same might be said if $0.01N$ NaOH were added. The solution of beef infusion is showing typical "buffer" action previously alluded to. Reference to the curve of Figure 2 will show that in the middle portion of the curve, at half neutralization, the addition of sodium hydroxide to the acetic acid changed the pH value but slightly, the solution in the beaker exhibiting buffer action.

The effects of buffer action may be shown as follows: suppose some methyl orange is added to distilled water and the solution is divided into three parts, one part being reserved for comparison. The solution is yellow. To the other two are added a few drops of dilute acetic acid, imparting a pink color indicating an acid condition. Now to one of the pair is added a few crystals of sodium acetate. The color reverts to the color of the portion kept as a comparator, showing that the concentration of the H^+ ion has been reduced by the sodium acetate to below the point where methyl orange will show the presence of H^+ ions. The addition of a few drops of even a strong acid does not change the color to the original

strong pink. The sodium acetate is acting as a buffer. Acetic acid is slightly ionized while sodium acetate is ionized to a much greater extent. The sodium acetate providing most of the acetate ions present, disturbs the ionization of the acetic acid, increasing the concentration of the acetate ions which combine with the H^+ ions to form undissociated acetic acid, and in so doing lowers the H^+ ion concentration, causing the disappearance of the pink color of the indicator.

It was pointed out in connection with Figure 2 that when the acetic acid was half neutralized the solution showed buffer action. Sodium acetate in water solution sets up the equilibrium:

$$Na^+ + C_2H_3O_2^- + H_2O \rightleftharpoons Na^+ + OH^+ + H{\cdot}C_2H_3O_2$$

and by itself would produce an alkaline reaction due to the presence of an excess of OH^- ions. At half neutralization H^+ ions are also present due to the unneutralized acid originally taken, and from the curve it is seen that at half neutralization the pH is 4.74, which is acid. If acid be added to this solution, the H^+ ions are taken up to form undissociated acetic acid, if OH^- ions are added the acetic acid reacts with it to form sodium acetate, thus removing OH^-. This solution is then acting as a buffer in the region of pH 4.7.

Buffer solutions may be prepared which will exhibit a definite range of pH values by mixing appropriate compounds in definite proportions and concentrations as:

	pH range
Acid potassium phthalate and hydrochloric acid	2.2–3.8
Acid potassium phthalate and sodium hydroxide	4.0–6.2
Acid potassium phosphate and sodium hydroxide	5.8–8.0
Boric acid and sodium hydroxide	7.8–10.0

Most of the buffer solutions contain a weak acid or base or a salt of a weak acid or base and mixtures of these. Such solutions by hydrolyzing and by reason of the common ion effect when mixed in definite known proportions give the variation of pH desired and at the same time provide the buffer effect. Solutions of definite known concentrations of such mixtures may be prepared and the accurate pH measured by potentiometer methods. To obtain a solution of definite pH the buffer solutions, such as listed above, may be made up and standardized by potentiometer methods showing intervals, say, of 0.2 pH.

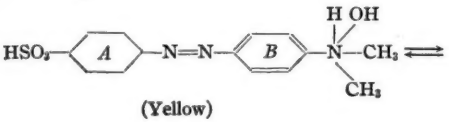
Indicators

Indicators are colored bodies, the color of which alters with the concentration of the hydrogen ion. To change from the acid color to the basic color requires a definite change of hydrogen-ion concentration; that is, the pH of the solution must exceed a certain minimum value. The addi-

tion of more base raises the pH of the solution, but beyond a certain point an increase of pH by the addition of more base will not cause any further change in the color of the indicator. Having the solution in this condition with an indicator present, adding acid will lower the pH and a point will be reached at which the acid color of the indicator appears. The addition of more acid intensifies the acid color, but again a point will be reached when the addition of more acid will not further alter the intensity of the acid color. With most indicators there is a definite range of pH values when both colored forms are present.

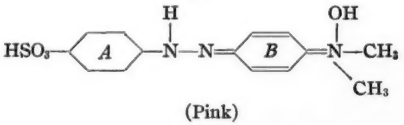
An elementary explanation of the causes underlying the changes of indicators may be given in the case of methyl orange. This indicator is yellow in neutral and alkaline solution and pink in acid solution. It has two tautomeric forms.

I



(Yellow)

II



(Pink)

When an acid is added to the solution the acid anion displaces the OH group of II*B* producing the pink form and the amount to which the pink form is produced is greater as the concentration of the acid is increased. This is at the expense of the yellow form I. In the presence of very little acid both forms may be present, but finally with the addition of more acid all of form I will be used up and all of form II will have reacted with the acid. From this point on, addition of more acid will not change the color of the solution.

On the other hand, suppose an alkali is added to the indicator. Under these conditions the sulfonate group, HSO_3, of *A* takes up the base to form a salt of the sulfonate group, favoring the formation of form I at the expense of form II and the solution changes to yellow. The same cycle is gone through in the reverse order.

In the case of methyl orange when the hydrogen-ion concentration is 2.1×10^{-4} or greater, the form II is in the preponderance. Remembering that,

$$[H^+] \times [OH^-] = 10^{-14}$$

the $[OH^-]$ concentration corresponding to this $[H^+]$ concentration is

$$2.1 \times 10^{-4} \times [OH^-] = 10^{-14}$$

$$[OH^-] = \frac{10^{-14}}{2.1 \times 10^{-4}} = 4.8 \times 10^{-11}.$$

Hence, although methyl orange is not sensitive to minute concentrations of hydrogen ions, it is very sensitive to hydroxide ions. Its end point is on the alkaline side. On the other hand, phenolphthalein is very sensitive to hydrogen ions, its turning point being, $[H^+] = 9.2 \times 10^{-9}$ with $[OH^-] = 1.1 \times 10^{-6}$. The turning point is on the acid side for phenolphthalein.

Clark and Lubs Indicators

While there are a host of indicators, Clark and Lubs have recommended a series given below which give a wide range of pH at which an intermediate shade of color is observed.

Common name	Color change *acid-alkaline*	pH range
Thymol blue (acid range)	Red–yellow	1.2–2.8
Brom phenol blue	Yellow–blue	3.0–4.6
Methyl red	Red–yellow	4.4–6.0
Brom cresol purple	Yellow–purple	5.2–6.8
Brom thymol blue	Yellow–blue	6.0–7.6
Phenol red	Yellow–red	6.8–8.4
Cresol red	Yellow–red	7.2–8.8
Thymol blue (alkaline range)	Yellow–blue	8.0–9.6
Cresol phthalein	Colorless–red	8.2–9.8

A series of buffer solutions are prepared showing a pH starting, say at 1.2, and in pH intervals of 0.2 ranging up to, say, pH 9.8. If to 10 cc. portions of these buffer solutions in similar test tubes 5 drops of the above indicator solutions of proper concentration are added, choosing the indicator in the pH range listed above, for each indicator there will be noted a gradual transition of color varying with the pH content of the tube. The color produced when an indicator is added to a solution of unknown pH, if the proper indicator be chosen, will show the approximate pH of the solution. This color may be matched with one of the test tubes containing the indicator and a buffer solution of known pH value. By such a comparison method an approximate value of pH may be obtained. The buffer solutions are standardized in the first place by potentiometer methods and potentiometer methods are required when greater accuracy is desired.

Application of Comparison Methods

Suppose we have a full set of buffer solutions made up and also a full set of indicators and it is required to approximate the pH of a culture medium. The culture medium may not be water white and may show a turbidity. To determine the pH of this culture medium we may proceed as follows:

The approximate pH is determined by adding to 10 cc. of the culture medium contained in the test tube, 5 drops of the indicators taken in succession until one of the indicators is found which is just on the turn. This test tube containing the culture medium and indicator is set in a comparator box, the plan view of which is given below.

Suppose the addition of indicator brom cresol purple to the culture medium showed that the pH was within its range. Hence, the pH is between 5.2 and 6.8. The 10 cc. of culture medium and indicator are placed in compartment *B* (Figure 3), and behind it in compartment *E* is placed a similar tube with 10 cc. of water. Two 10 cc. portions of the culture medium are poured into test tubes and introduced into compartments *A* and *C*, while in compartments *F* and *D* are tried portions of buffer

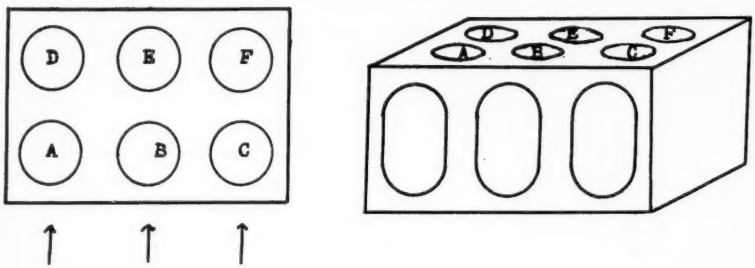


FIGURE 3

solutions having a pH value between 5.2 and 6.8, together with 5 drops of the indicator. The tubes are viewed in the direction of the arrows in the plane of the paper. It will be found that the same tint of color, called the virage, is produced, let us say, when *F* contains a buffer of pH 5.6 and *D* a buffer of pH 5.8. The colors shown by the culture medium tube are closely matched by the pair of tubes on each side. The conclusion is that the pH of the culture medium lies between 5.6 and 5.8.

It is common to have on hand a set of buffer solutions in test tubes with the proper indicators, sealed off and kept as comparators.

The object of viewing the color through two tubes was to remove any error due to the color or turbidity of the culture medium. By this method the colors of the known and unknowns were viewed under the same conditions.

Test for Glycogen. Announcement was made at the Swampscott meeting of the A. C. S. of a new test for minute amounts of glycogen, the substance stored in the liver to be converted, as the body requires, into sugar. Arnold E. Osterberg has developed a test for determining the presence of glycogen in extremely small amounts of tissue.—*Science Service*

SOME NOTES ON VARIOUS ELECTROLYTES

The word *alkali* is of Arabic origin and is derived from *Kali*, the name of a plant. This plant was burned and the ashes extracted with water to obtain carbonates of potassium and sodium which were used in soap-making. No distinction between soda and potash was recognized until the middle of the eighteenth century. The Greeks and Romans originally obtained sodium carbonate by evaporating alkaline waters from arid regions and called it *nitron* or *nitrum*, respectively. Later they gave the same names to the carbonates (chiefly potassium) derived by leaching wood ashes.

Soda is apparently from the old Italian, but its exact origin is uncertain.

The term *potash* is of comparatively recent origin and was derived from the fact that the leachings from wood ashes were concentrated in iron pots.

The ancients did not distinguish between acids any more than between alkalies. *Acid* is from *acidus*, the Latin word for sour.

Since the alkalies known in early times were practically all obtained in the form of carbonates, it is not surprising that they were once defined as substances which "fermented" or effervesced with acids.

Some of the earlier theories concerning the interaction of acids and alkalies are weird in the light of present knowledge. In 1683, Dr. Bertrand wrote:

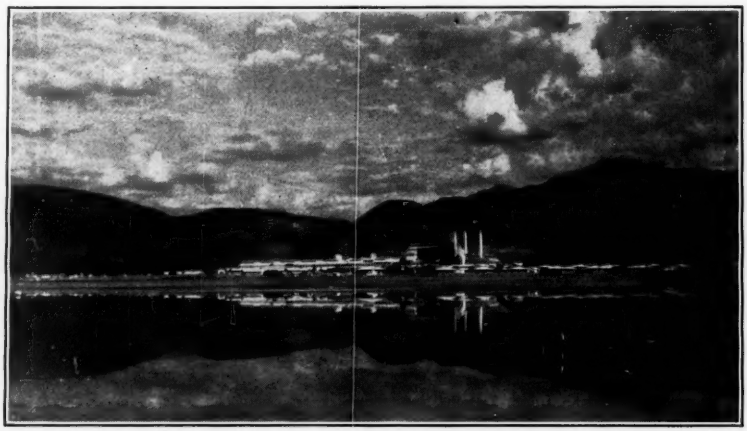
"I say that an acid is a liquid body composed of small firm and pointed particles, slightly resembling very fine and delicate needles. This idea accords exactly with all the actions of which we see acids to be capable. For by its particles of such a shape it excites a prickling when applied to the tongue, and is fitted to cause effervescence when mixed with certain bodies which it penetrates, and of which it violently disturbs the particles. Some of these it dissolves by disturbing and breaking up the tissues in penetrating their pores, and others it coagulates by becoming entangled in their branching and irregular particles, as occurs with milk. Moreover, as acids are not all entirely alike, as their particles may have different sizes and points more or less fine, it should follow that they ought not to dissolve every sort of body indifferently, but only those the pores of which are accommodated to their shapes, and the textures of which cannot resist their force and activity. We see therefore that *aqua fortis* which dissolves silver cannot dissolve gold, and that distilled vinegar while it dissolves lead cannot act on mercury.

"Alkali, on the contrary, should be a solid earthy body the particles of which have between their junctions pores of different structure. It is for this reason it can be dissolved by an acid, and that it effervesces with it

and blunts its points: that it cleans cloth and is capable as alkali of some other actions that experience teaches us to recognize. But it is only by reason of this particular contexture that it accomplishes these."[1]

The manufacture of potash was one of the earliest American chemical industries. As early as 1600 Europe was beginning to feel the pinch of potash shortage. The enormous forest resources of the new world and the necessity of clearing land for cultivation led to the hope that the American colonies could supply the demand. After many unsuccessful attempts a thriving trade was established here. Smith's "History of Pittsfield" describes the process.

"The wood was usually cut into lengths of 8 or 9 feet, piled in heaps con-



PLANT OF THE AMERICAN POTASH AND CHEMICAL CORPORATION AT SEARLES LAKE, CALIFORNIA

taining from 1 to 3 cords, and, when half dry, burned. The ashes were placed in large tubs whose bottoms were covered 6 or 8 inches deep with brushwood, above which was a 3 inch layer of straw. Water was then filtered through the mass, till all the soluble matter was carried off in the lye which passed through an aperture in the bottom of the tub into a proper receptacle.

"This lye was then placed in large iron kettles, and boiled until the evaporation left the matter held in solution in a solid form—a dark, almost black, crust known to the workmen as brown salts, having a strong alkaline taste. These salts consisted of a very large proportion of potash mixed with more or less carbonaceous matter, vegetable salts, and a little earth.

[1] *Reflections nouvelles sur l'acide et sur l'alcali*, **1683.**

This mass was thrown into a cast-iron kettle of considerable thickness, and subjected to a red heat for 1 to 2 hours and most of the combustible matter was consumed. The residuum, when cold, was broken up, packed in tight casks, and sent to market—the American potash of commerce. It contained from 5 to 25% of pure potash with impurities in various proportions, depending very much upon the care exercised in collecting the ashes after the burning of the wood."

This trade was interrupted during the war of 1812 and was never reestablished because of inability to compete with the Le Blanc soda process which was devised at about that time.[2]

The increasing cost of alkalies of vegetable origin in Europe led Napoleon to offer a prize for a new process for producing alkali. Le Blanc came forward with the process which bears his name. It consisted in heating sodium chloride with sulfuric acid to form sodium sulfate and hydrochloric acid. The sodium sulfate was converted to carbonate by heating with limestone and coal.

It is said that Le Blanc never received the promised award and that he subsequently died in poverty.

From a publication of the Solvay Process Co.

ERNEST SOLVAY, ORIGINATOR AND PERFECTOR OF THE SOLVAY PROCESS FOR THE MANUFACTURE OF CARBONATE OF SODA

The Le Blanc process has been largely replaced by the Solvay process, introduced in 1866 by Ernest Solvay. The latter process involves the following reactions:

$$CO_2 + NH_3 + H_2O \longrightarrow (NH_4)HCO_3$$

$$NaCl + (NH_4)HCO_3 \longrightarrow NH_4Cl + NaHCO_3$$

$$2NaHCO_3 \longrightarrow Na_2CO_3 + H_2O + CO_2$$

Because of its value in agriculture, potassium is no longer a source of alkali. Alkalies are now made almost exclusively from the cheaper and more readily obtainable sodium salts.

The chief sources of agricultural potash are the Stassfurt salt deposits of Germany. America is again developing a potash industry, however. The

[2] For a fuller account of the early potash industry of America see "Historical Notes upon the Domestic Potash Industry in Early Colonial and Later Times," C. A. Browne, THIS JOURNAL, **3**, 749–56 (July, 1926).

largest source of American potash is the concentrated brine of Searles Lake, California. By carefully controlled evaporation and a series of suc-

AN EXAMPLE OF SALT SCULPTURE—THE CHAPEL OF SAINT ANTHONY AT WIELICZKA, POLAND

cessive crystallizations, potassium salts and several by-products are obtained.

Minor sources are the residues from molasses fermentation for the production of industrial alcohol, and slag from blast furnaces.[3]

Some sodium hydroxide is now made by the electrolysis of sodium chloride solution. This can hardly be classed as an alkali industry, however, for its success is dependent upon a good market for the chlorine simultaneously obtained. From an economic standpoint chlorine is the main product and alkali a by-product. If alkali alone is required, the Solvay process is the more profitable.

The rock-salt mines of Poland are among the most interesting in the world. The salt is about 99% pure NaCl and requires only pulverizing to fit it for table use. It is mined in large blocks, and cubes weighing as much as eight tons are brought to the surface.

In some of the mines galleries, chapels, and ballrooms have been carved from the solid salt and adorned with pillars and statuary sculptured from the same material.

The first sulfuric acid plant in America was established and operated by John Harrison, a pupil of Priestley, at Philadelphia in 1793. It produced about three carboys of acid a day. The plant was enlarged in 1807 by the construction of a larger chamber but was destroyed by fire about two years later. A second plant was built, and consumed about one ton of Sicilian sulfur a day.

A recent study at the University of California[4] on the washing of milk bottles indicates that absolute sterility can be obtained with surprisingly low concentrations of alkali. Bottles immersed for four minutes in a solution containing 0.7% of NaOH at a temperature of 48.8°C. were found to be entirely free from bacteria.

[3] For a more complete discussion of the sources and uses of potash see "Potash," R. Norris Shreve, THIS JOURNAL, **4**, 230–4 (Feb., 1927).

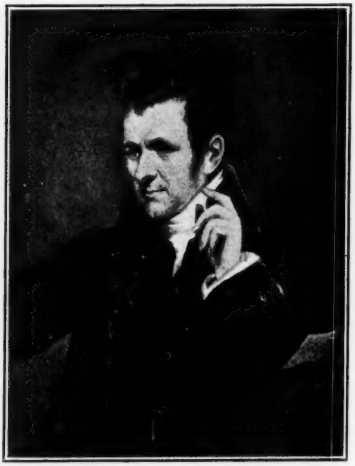
[4] C. S. Mudge and B. M. Lawler, "Effect of Alkali Solutions on Bacteria Found in Unwashed Milk Bottles," *Ind. Eng. Chem.*, **20**, 378–80 (April, 1928).

Survey of Dye Industry. The U. S. Tariff Commission is preparing a survey of the domestic dye and synthetic organic chemical industry, representing the results of a special investigation of the production in the United States of coal-tar dyes and synthetic organic chemicals, both of coal-tar and non-coal-tar origin. The survey will include a detailed tabulation of coal-tar dyes imported into the United States and also official statistics of imports and exports by the large consuming and producing nations of the world.— *News Edit., Ind. Eng. Chem.*, **6**, 2 (Oct. 20, 1928).

SIR HUMPHRY DAVY

Humphry Davy was born, December 17, 1778, in the Cornish town of Penzance, familiar to most of us, in name at least, through the Gilbert and Sullivan opera, "The Pirates of Penzance." His formal schooling was brief and somewhat sketchy. When he was sixteen his father died and the family circumstances—never more than moderate—did not improve. Accordingly he was apprenticed to a physician of that locality, with whom he remained for some years, although not for the complete term of his apprenticeship.

Whether his employer kindly released him to enable him to seize a more favorable opening or, as one author has hinted, in order to be rid of the nervous strain occasioned by Davy's sometimes disastrous chemical experiments, we cannot positively say. At any rate, we find Davy next as assistant to Dr. Beddoes at the Pneumatic Institution at Bristol.



SIR HUMPHRY DAVY, P.R.S.
From the Portrait by Lonsdale.

The researches of Priestley and others on gases had inspired a new medical fad. The Pneumatic Institution was founded for the purpose of testing the usefulness of various gases as medicines. Davy undertook the functions, not only of an investigator, but of a laboratory animal as well, for he accomplished many of his tests by personally inhaling the gases prepared. In this way he discovered the physiological properties of nitrous oxide, called "laughing gas" because of the hysteria which is one of its after-effects. Apparently the anesthetic potentialities of the gas were not appreciated at that time for it was not used as an anesthetic until much later.

Some of Davy's other experiments did not result so happily for he inhaled several gases which we now know to be very poisonous. Fortunately for science, he escaped with his life, but not without some damage to his health.

In the meantime the Royal Philosophical Institution had been founded at London, largely through the efforts of Count Rumford, and Davy was offered the post of assistant lecturer and experimenter to the Institution, with prospects of ultimately becoming sole professor of chemistry. He

accepted this post at the age of twenty-three, and began the series of public lectures and experiments which were to prove so popular.

Davy was a young man of good appearance and pleasing personality but he did not rely upon these qualities to win him the favor of his audiences. His experiments were planned with infinite care, as were his lectures, and he rehearsed both before his assistants.

In the matter of research the young experimenter was not given altogether free rein. The Institution had a number of pet problems which it was his duty to undertake, and he investigated them quite competently. He also found time, however, to begin the experiments which later raised him to eminence in the chemical world. These were his experiments on electrolysis, which reached their climax in the discovery of potassium and sodium.

He had begun by electrolyzing solutions. When he investigated solutions of the alkalies, however, he found that water was decomposed into hydrogen and oxygen—the alkalies were apparently unattacked. Accordingly he adopted a somewhat different technic.

"A small piece of pure potash, which had been exposed for a few seconds to the atmosphere, so as to give conductive power to the surface was placed upon an insulated disk of platina, connected with the negative side of the battery in a state of intense activity; and a platina wire communicating with the positive side was brought in contact with the upper surface of the alkali....

"Under these circumstances a vivid action was soon observed to take place. The potash began to fuse at both its points of electrization. There was a violent effervescence at the upper surface; at the lower, or negative surface, there was no liberation of elastic fluid;[1] but small globules, having a high metallic luster, and being precisely similar in visible characters to quicksilver, appeared, some of which burnt with explosion and bright flame, as soon as they were formed, and others remained, and were merely tarnished and finally covered by a white film which formed on their surfaces.

"Soda, when acted upon in the same manner as potash, exhibited an analogous result; but the decomposition demanded greater intensity of action in the batteries, or the alkali was required to be in much thinner and smaller pieces.

"The substance produced from potash remained fluid at the temperature of the atmosphere at the time of its production;[2] that from soda, which was fluid in the degree of heat of the alkali during its formation, became solid on cooling, and appeared having the luster of silver."

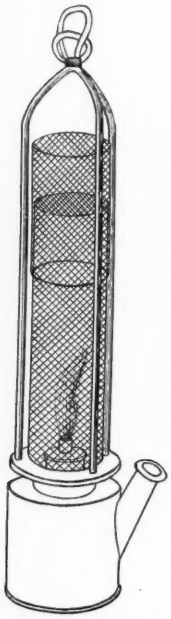
[1] The earlier chemists sometimes spoke of gases as "elastic fluids."

[2] Probably the potassium first obtained by Davy was alloyed with sodium, due to the impurity of the alkali employed. A potassium-sodium alloy is liquid at room temperature, but neither sodium nor potassium is.

It remained for the new elements to be classified and named.

"Should the bases of potash and soda be called metals? The greater number of philosophical persons," he says, "to whom this question has been put, have answered in the affirmative. They agree with metals in opacity, luster, malleability, conducting powers, as to heat and electricity, and in their qualities of chemical combination.

"Their low specific gravity does not appear a sufficient reason for making them a new class, for amongst the metals themselves there are remarkable differences in this respect. . . . . In the philosophical division of the classes of bodies, the analogy between the greater number of properties must always be the foundation of arrangement.



ONE OF DAVY'S SAFETY LAMPS

"On this idea, in naming the bases of potash and soda, it will be proper to adopt the termination which by common consent has been applied to other newly discovered metals, and which, though originally Latin, is now naturalized in our language.

"Potassium and sodium are the names by which I have ventured to call the new substances, and whatever changes of theory, with regard to the composition of bodies, may hereafter take place, these terms can scarcely express an error; for they may be considered as implying simply the metals produced from potash and soda. I have consulted with many of the most eminent scientific persons in this country upon the methods of derivation, and the one I have adopted has been the one most generally approved. It is perhaps more significant than elegant. But it was not possible to found names upon scientific properties not common to both; and though a name for the basis of soda might have been borrowed from the Greek, yet an analogous one could not have been applied to that of potash, for the ancients do not seem to have distinguished between the two alkalies."

Davy also investigated the greenish gas discovered by Scheele and by him called *dephlogisticated marine acid air*. Lavoisier had studied the same gas and called it *oxymuriatic acid*. It was Lavoisier's notion that all acids must contain oxygen. This greenish gas and hydrogen were the components of *muriatic*[2] acid, hence, so Lavoisier thought, the gas must be the oxide of an unknown element.

No doubt Davy suspected the gas of being, itself, an element. It is certain that he did not believe oxygen to be an essential constituent of

[2] Hydrochloric.

acids. He treated the gas with a wide variety of substances known to have great affinity for oxygen and showed that the resultant compounds were not the oxides of the reagents employed. Although he did not prove that chlorine was an element he showed that it was not decomposable by any means which he could devise. He cautiously refrained from making any claims which his work was insufficient to support and named the gas *chlorine* because of its color.

It is interesting to note, also, that Davy produced the first carbon arc, although he did not attempt to make any practical use of it. In fact, the use of the carbon arc for lighting purposes would have been distinctly impractical in his day, for no economical or constant sources of current were available.

The Davy safety lamp, in which the flame is protected from explosive external gases by means of a wire gauze, has been employed almost universally by miners.

STUDENT CONTRIBUTIONS

Is your chemistry club carrying on some worthwhile project? Have you, yourself, an interesting chemical hobby? Have you devised an original chemical experiment or piece of apparatus? Have you built a working model of a chemical plant or a piece of chemical machinery? Have you a chemical collection of any kind?

Tell us and other students about it in an article of not more than one thousand words. If possible, illustrate your article with drawings or photographs, or both. In preparing your manuscript, observe the directions to authors set forth on page 1534.

Ten dollars will be awarded the high-school or undergraduate college student contributing the best item received on or before January 15, 1929. Five dollars will be paid for any other articles accepted for publication. Address your contribution to the Associate Editor, JOURNAL OF CHEMICAL EDUCATION, the Johns Hopkins University, Baltimore, Md.

Increased U. S. Tariff on Barium Carbonate. The cost, in the United States, of producing precipitated barium carbonate used in the manufacture of enamel wall paints and optical glass, exceeds the cost of production in Germany, the principal competing country, stated the United States Tariff Commission, in a report to President Coolidge. Accordingly the president, upon the findings of the Commission, proclaimed a 50 per cent increase in the tariff. The Commission's report resulted from a cost of production investigation which it instituted upon applications from the Bertha Mineral Co., of Newark, N. J.; the Barium Reduction Co., of Charleston, W. Virginia; and the Chicago Copper and Chemical Co., of Blue Island, Illinois.—*Chem. Age*, **19**, 289 (Sept. 29, 1928).

A UNIQUE LABORATORY*

FRANCIS P. FLEMING, ST. CHARLES SEMINARY, CARTHAGENA, OHIO

The chemical laboratory is so intimately connected with the science of chemistry, that, without experimentation, the true spirit of the science cannot possibly be acquired. When the name chemist chances to reach the ear, there is conjured up in the imagination a picture of a man wearing a rubber apron, perhaps rubber sleeves and gloves, and mixing together various kinds of "liquors." In the minds of all, the scientist is surrounded with the complete environment of the laboratory. And this is only as it should be, for the "workshop of the chemist" is a *sine qua non* condition, not only for the acquisition of productive knowledge in the veriest of tyros, but also for the fructifying of that knowledge in the greatest of masters. Chemistry, which has so changed the face of the world, has evolved from the hidden recesses of chemical laboratories.

But, here were we, just one year ago this month, two enthusiastic devotees of chemistry, ready for intensive work in the science, most anxious to plunge into its depths—and no place was at hand in which we could do our "plunging;" no laboratory tempted us to try our skill. The one year of general chemistry offered to us during college days had served to whet our appetities most keenly for more. But what course was open to us, when all avenues leading to the fulfilment of our ideals seemed closed? Only one, and that was to build a laboratory of our own. We pooled our resources, therefore, and decided that if all went well, we were going to have that laboratory.

Before starting upon any definite program, we had to determine what line of chemistry, descriptive or analytic, would be most beneficial to us. Upon the advice, and with the promise of the continuous help of our former instructor, it was decided to enter the analytic field, the text of A. A. Noyes on "Qualitative Chemical Analysis" being chosen as our guide. Accordingly, all plans for laboratory equipment were made in such a way as to facilitate the attainment of this end. By judicious buying, we obtained, with our limited resources, all the necessary apparatus, and a supply of chemicals which would last for the next five years; serving not only for the one-year course of analytical chemistry, but also for anything that we should care to undertake thereafter.

Under our eager hands, the laboratory gradually took definite form. A handy work-table was erected, shelves for the chemicals, a hood to take out the various unnecessary fumes, in fact everything that was recommended to us by an able analyst as tending to simplify and perfect manipulation. The work-desk was covered with a plate of Venetian glass, and I

* Winner of ten-dollar award in the student contribution contest closing November 15, 1928.

must say that this plate has done more to keep the laboratory in a neat condition than anything else devised for that purpose. A very simple hydrogen sulfide generator was manufactured out of a large wide-mouthed bottle and a lamp chimney, according to the directions outlined in that *vade mecum* of analysts, the manual of Fresenius. After much "wracking of brains" a suction pump for filtration was constructed from an old automobile pump by reversing the plungers and the valve. Though crude, it is very efficient, most admirably serving the purpose for which it was devised. The laboratory was now nearly complete, and when linoleum was laid on the floor, a bookcase and study-desk installed, we considered ourselves very comfortably situated for the real work that was yet to come.

Fully one-half of the chemicals with which our shelves are stocked were made, purified, crystallized, and recrystallized by our own hands. This was done, not only for the sake of the experience which we derived from it, but also to effect a saving in the cash outlay, which had to be made from very limited resources. The solutions as required according to the method of A. A. Noyes having been most carefully prepared, we deemed everything to be in order. The laboratory was in such shape as to invite us to "fall to" without delay. We were ready to begin our study of one of the most interesting and useful forms of chemical science, *viz.*, analysis.

It may easily be imagined with what great trepidation we began our first work. And surely we had cause to tremble, for we were undertaking a task without one of the most valuable of assets, the supervisor. We plunged, however, and all has not been in vain. In three months of spare time, we have finished the first three parts of the course, namely, the silver, the copper-tin, and the aluminum-iron groups. To use the intellect as well as the memory is the chief object which we have placed before ourselves. Stieglitz's admirable course in the theory of qualitative analysis, we have tried to absorb thoroughly, and with its information, to explain in detail each step taken. The course cannot therefore be called mechanical. References to numerous other authors, such as Fresenius, Treadwell, McPherson, and parts of THIS JOURNAL, have been made with the object of simplifying the analyses as much as possible, but still retaining every item necessary for complete and accurate analysis of a specimen. Since the first part (which extensive reading has convinced me is the most difficult) has been passed with such zest and success, we are looking to the future with confidence supreme.

The first (silver) group, with all its principles of complex ions and common-ion effect, was certainly a most interesting and enlightening introduction. Most of the theories exemplified in qualitative analysis, especially the mass law, had been running hazily through my mind as they were enunciated in the various general chemistry texts whose acquaintance I had

been fortunate enough to make, namely, Smith, Remsen, and Mellor. But analytical work brought these theoretical notions into practical actualities. In the manipulative procedure, not much divergence was made from the method of Noyes. His procedure, together with his notes and questions on the procedure, do not leave much to be desired.

The second (copper-tin) group, however, was not so simple. The manipulation demands extreme care, and the principles of solubility-product and fractional precipitation come into play to such an extent, that if one has not mastered the mass law before taking up the group, he surely must know it afterward. The second group as a whole is most neatly worked out by Noyes. A few changes, however, were made in order to satisfy my sense of simplicity and accuracy. The repression of the copper ion for the determination of cadmium was effected by the formation of the complex $Cu(CN)_2^-$ ion with KCN, rather than by the reduction of the ion with Fe powder. No difficulties were experienced by the substitution of this much simpler method. The confirmatory test for bismuth was also found to need improvement for the sake of greater accuracy. The test involves the use of sodium stannite. We are directed in the text to mix carefully $SnCl_2$ and NaOH, and then to apply the Na_2SnO_2 thus formed to the supposed $Bi(OH)_3$ in the filter. A black coating of metallic Bi will be formed on the filter paper if the sodium stannite is in good condition. But we cannot always be absolutely sure of the condition of the Na_2SnO_2, so that the results obtained are rather precarious. If, instead, the supposed $Bi(OH)_3$ on the filter is first moistened with NaOH, and then with $SnCl_2$ there is no chance for the Na_2SnO_2 to decompose without effect, and consequently, the results will be much more certain. I can safely recommend this procedure to any one who has experienced any trouble with Noyes' confirmatory test for bismuth.

Somewhat farther than this, indeed, have we gone in our determined effort to acquire an adequate knowledge of analysis, but the narration of our activities in the third group, and the demonstration of the numerous advantageous changes effected therein would form material for another and more lengthy article. The past is gone, and the future lies before us. Who can say what it will hold for us? It is uncertain, indeed, but looking back upon the success of the past, we are imbued with great confidence. The work entailed is great, to be sure, but the interest and utility of the science can but lure one on to the end—"He who desires the end, desires the means." We hope for the best. With the closest contact with authority that is in our power, we shall struggle onward toward our ideal, trusting that our interest in the science may in time render us capable of contributing our small part in its great purpose—the advancement of civilization.

THE WATER SUPPLY*

D. W. PRICHARD, 5322 N. 12TH ST., PHILADELPHIA, PENNSYLVANIA

The water supply is an admirable topic to be studied by a city high-school chemistry club. It is now being studied by the Chemistry Club of the Northeast High School of Philadelphia.

The first step taken by the club under the supervision of two members of the faculty was to divide its members into committees. Eight committees were suggested: (1) a committee to study the history of the water supply, (2) a committee to study the sources of water supply, (3) a committee to study the distribution of water, (4) a committee to study the health problem, (5) a committee to study the analysis of water, (6) a committee to study the contamination of water, (7) a committee to study the purification of water, (8) a committee to supply the club with pictures desired by various other committees, (9) a committee to prepare a map showing the location of the various stations of the water bureau, and (10) a committee to study the relation of the water system of Philadelphia to the water systems of other large cities.

Each committee is to prepare a report covering its field of study. Committees number 8 and 9 are of course exceptions.

The reports are to be edited under the guidance of the faculty advisors and published in pamphlet form. If the work is well done the pamphlet will be used by the chemistry classes of the school.

Material for reference may be obtained from the public libraries and from the state and government printing offices. Additional and most important information was obtained by interviewing the chief of the water bureau and obtaining his permission to visit the plants and laboratories, and to have access to any references owned or published by the water bureau.

This project has been carried out by several other schools with great success and due to our sources of information we are confident that our work will be valuable to us and the succeeding classes of the school.

* Winner of five-dollar award in the student contribution contest closing November 15, 1928.

Monument to Pasteur Dedicated at Chicago. A monument to Louis Pasteur, the French bacteriologist, was unveiled on the lake front at Chicago on October 27th, amid impressive ceremonies in which Vice-President Dawes and the French Ambassador, Paul Claudel, and his daughter, Reine, took part.

The monument, of Italian marble, stands at the west end of the Field Museum of Natural History. It was designed by Leon Hermant, a sculpture of Chicago.

At the monument was William T. Lane, Irvington, N. J., who sailed for Paris on December 9, 1885, to become the first American treated for rabies by Pasteur.

Correspondence

AN IMPROVED HOT-WIRE GLASS CUTTER

I was surprised to find that Baker and Haldeman, in their description of "An Improved Hot-Wire Glass Cutter" in the October issue of the JOURNAL OF CHEMICAL EDUCATION, state that their cutter cannot be used for Pyrex glass. I have been using a cutter similar to this for the last two years and have consistently cut Pyrex glass tubing up to two inches in diameter. All that is necessary is to have a scratch (preferably made with a glass knife) running clear around the tube, and then, when the circumference has been well heated with the wire, drop on the scratch a little water from a pipet.

GREGG M. EVANS

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VOCATIONAL INFORMATION THROUGH CHEMISTRY

Some time ago Mr. Graves, the Commissioner of Education of the State of New York, issued a statement to the effect that Continuation Schools in New York are of a secondary nature. The question arises as to what subjects of a secondary nature can be taught in a Continuation School which will be of practical use to the boy in understanding some of the many processes used in industry.

One of the purposes of the Continuation Schools is to guide the boy as much as possible by giving him an idea of the different trades in order that he may make a choice of that which interests him most.

A course given at the Brooklyn Boys' Continuation School is *The Practical Chemistry Course.* The object of this course is not to make chemists of the boys, but to give them an elementary idea of the different chemical processes used in industry. The course is given to the boys of the automobile class, so that they may understand the importance of chemistry to automobile manufacture. It is a well-known fact that chemistry today is the basis of industry but how many appreciate that fact? It is about time, I think, that chemistry from a vocational viewpoint should be stressed. By learning how important chemistry in industry is, a boy can appreciate much more the processes used in making a piston, a rubber tube, or a glass shield.

The methods used in teaching this subject are: the forum method, the

concrete method, and the question-and-answer method. At each period the lesson is made as complete and independent a unit as possible. The topic and reference for subsequent periods are given so that each pupil may look up these topics and then discuss them in class. Demonstrations are used with the purpose of having the boys draw their own conclusions; *i. e.*, to enable them to discern causal relationships and to realize the importance of doing things in a logical way.

No laboratory work is given, the demonstrations being given by the teacher. The boys would, if laboratory work were given, be able to develop self-confidence in their ability and arrive at independent conclusions.

Typical Outline of a Lesson

Title: Making steel.

Materials used and their geographic distribution: Iron ore from Michigan, Minnesota, and Wisconsin; limestone from Michigan; coke from Pennsylvania and West Virginia; air preheated to 1500°F.

Blast furnace method: (1) The structure of a blast furnace (this is described and shown by means of large sketches, and a furnace is shown charged with the above materials); (2) preheated blast air received from heaters (here the chemical action is described); (3) collection of molten iron (pig iron); (4) disposal of the slag.

Refining the molten iron (pig iron): Description, the heat required, purpose—elimination of excess carbon and impurities, separation of the slag from the steel, pouring off the molten steel into ingots.

The importance and composition of the different grades of iron and steel as used in the automobile are also studied.

J. F. PADULA

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Trace Ancient Metal Trade Routes by Chemical Analysis. Solving the riddle of ancient trade routes with test tube and chemical spectroscope is the surprising procedure reported before the British Association for the Advancement of Science at Glasgow by a committee of museum workers headed by H. J. E. Peake.

Archaeologists wanted to know where the men of Sumer, oldest of Mesopotamian kingdoms, got their copper. The records written in the bricks do not tell. So metallurgical chemists analyzed the weapons and implements these ancients used, and then sought through all the parts of Asia round about for copper deposits that would match their analyses.

The Sumerian copper contained a little nickel as an impurity, and the search for a vein of copper ore that contained nickel was taken up. It proved to be a long one. Ores from Persia, the Black Sea region, the Sea of Marmora, Cyprus, Egypt, and Sinai were examined, but yielded no nickel. Finally, an ore of the right quality has been found in the State of Oman, on the Persian Gulf corner of the Arabian peninsula.—*Science Service*

Chemical Digest

THIS MODERN CULTURE

In a recent article, "The Cultivated Man,"[1] Dr. Charles W. Eliot discusses the modifications made by the past century in the ideal of culture and the means of attaining that ideal which the modern system of education offers. Accepting Matthew Arnold's dictum that "educated mankind is governed by two passions—the passion for pure knowledge and the passion for being of service or doing good," Dr. Eliot maintains that the nineteenth century's most significant contribution to the realization of these desires has been the scientific method of inquiry, and he quotes an admission of present-day humanists that "an interpenetration of humanism with science, and of science with humanism, is the condition of the highest culture."

He indicates the elements that mold our latter-day man of culture as (1) the formation of character in the "stream of the world." "The stream," he says, "is what it has been, a mixture of foulness and purity, of meanness and majesty; but it has nourished individual virtue and race civilization." (2) An extensive knowledge of some great literature and the power to use at least one's native language with elegance and accuracy. (3) Assimilation of some part of the store of human knowledge.

> What portion or portions of the infinite human store are most proper to the cultivated man? The answer must be: those which enable him, with his individual personal qualities, to deal best and sympathize most with nature and with other human beings. It is here that the passion for service must fuse with the passion for knowledge. It is natural to imagine that the young man who has acquainted himself with economics, the science of government, sociology, and the history of civilization in its motives, objects, and methods, has a better chance of fusing the passion for knowledge with the passion for doing good than the man whose passion for pure knowledge leads him to the study of chemical or physical phenomena, or the habits and climatic distribution of plants or animals. Yet, so intricate are the relations of human beings to the animate and inanimate creation that it is impossible to foresee with what realms of nature intense human interests may prove to be identified. Thus the generation now on the stage has suddenly learned that some of the most sensitive and exquisite human interests such as health or disease, and life or death for those we love, are bound up with the life histories of parasites on the blood corpuscles or of certain varieties of mosquitoes and ticks. When the spectra of the sun, stars, and other lights began to be studied, there was not the slightest anticipation that a cure for one of the most horrible diseases to which mankind is liable might be found in the x-rays. While, then, we can still see

[1] *The Golden Book Magazine*, **8**, 485–90 (Oct., 1928).

that certain subjects afford more obvious or frequent access to means of doing good and to fortunate intercourse with our fellows than other subjects, we have learned that there is no field of real knowledge that may not suddenly prove contributory in a high degree to human happiness and the progress of civilization, and therefore acceptable as a worthy element in the truest culture.

(4) Dr. Eliot emphasizes as a final essential in the preparation of the cultivated man the training of the imagination. "Constructive imagination," he argues,

> is the great power of the poet as well as the artist; and the nineteenth century has convinced us that it is also the great power of the man of science, the investigator, and the natural philosopher.... The educated world needs to recognize the new varieties of constructive imagination... the kind which conceived the great wells sunk in the solid rock below Niagara that contain the turbines, that drive the dynamos, that generate the electric force that turns thousands of wheels and lights thousands of lamps over hundreds of square miles of adjoining territory; or the kind which conceived the sending of human thoughts across three thousand miles of stormy sea instantaneously, on nothing more substantial than ethereal waves..... They are calm, accurate, just and responsible; and nothing but beneficence and increased human well-being results from them. There is room in the hearts of twentieth-century men for a high admiration of these kinds of imagination, as well as for that of the poet, artist, or dramatist.

In his opening paragraphs, Dr. Eliot remarks that our system of popular education has to do,

> ....not with the highly gifted units, but with the millions who are more or less capable of being cultivated by the long, patient, artificial training called education. For us and our system the genius is no standard, but the cultivated man is. To his stature we and many of our pupils may in time attain.

He concludes, however, with an admonition to the teaching profession, that it should not expect to produce this finished type in any high ratio.

> We seldom find combined in any human being all the elements of the type.... We must not expect systematic education to produce multitudes of highly cultivated and symmetrically developed persons; the multitudinous product will always be imperfect.. Let us as teachers accept no single element or kind of culture as the one essential; let us remember that the best fruits of real culture are an open mind, broad sympathies, and respect for all the diverse achievements of the human intellect at whatever stage of development they may actually be—the stage of fresh discovery, bold exploration, or complete conquest.

Turning from this contented survey, we find Dr. Bernard DeVoto, in "Tools for the Intellectual Life,"[2] taking a particularized and by no means satisfied view of the means of culture available in the modern college system to the young man who looks upon education "as the process by which one's mind is given discipline and discrimination, orientation in the modern world and understanding of it, and the adult ability to derive satisfaction from knowledge and from the pursuit of knowledge for its own sake."

[2] *Harper's Magazine*, **941**, 602–9 (Oct., 1928).

Dr. DeVoto seems to have chosen a still purer type, one with a single passion, unhampered by that desire for service, "the omnipresent sense of social obligation" which Dr. Eliot stresses. From the path of this youth, admitted to be so nearly hypothetical as to represent not more than one per cent of all undergraduates, Dr. DeVoto sweeps, with a determined program, the "fetish of the degree." This selected student lacks

> the indolent concept of education as an entity whose achievement can be blown in the bottle or stamped on the label. . . . All he asks of his college is that he be allowed to take there the first steps toward a method of thinking which he hopes eventually to make habitual—to put under way a process which will continue and, ideally, will accelerate during the rest of his life. In other words, his demand is that he be made familiar with the capacities and limitations of certain intellectual tools, and that he be given sufficient practice with them to master the technic with which they may be effectively employed. Leaving college at the end of the traditional four years, he will not be an educated man, not a man warranted complete in the intellectual life, but a man who has, in the process of learning to use the tools of knowledge, acquired some knowledge perhaps, but primarily the means of acquiring more.

Dr. DeVoto advocates the facile use of the tool of linguistic proficiency for a proper concept of the modern world and of a man's place in it. He recommends mathematics (but only to those naturally adapted to it) as a help

> toward the great goal of intelligent men, impersonal thinking. If he has a turn for mathematics and develops it sufficiently, he will eventually be able to think of phenomena purely as phenomena. He will then be able to bring to the chaos of thinking one of the most effective tools for the resolution of chaos. He will have a considerable reward, also, in his ability to understand mathematical thinking in fields outside the traditional ones of mathematics.

The third essential, says Dr. DeVoto, is the study of science. Physics, chemistry, and zoölogy are recommended

> . . . . on the ground that they deal directly with basic properties of matter and with basic properties of life—with the reality of the objective world. . . . . The essential is that the student study as much science as possible. . . . . till he knows and understands the concepts of science, the methods of science, the results of science—and, let me add, the true nature of what science is not as well as what it is, its limitations, and the problems that it does not hope to solve.

With the mastery of these tools, Dr. DeVoto considers his student ready for the invasion of the fields of history and literature, but in these,

> He will avoid courses . . . he can do better by himself. This is not to say that he will avoid the men who give the courses. He must regard them as specialists, to be freely consulted for guidance. . . . He needs expert guidance not only for bibliographical purposes but also to avoid the disaster of undirected reading on routes already charted. In such a plan of education. . . . perpetual wrangling is a necessity. Education becomes a series of disputes with men who know more than oneself—a sustained contention with experts while one tries to make oneself an expert as well.

Since Dr. DeVoto admits this one element in the modern college, the contact of professor and student, as a formative influence for his young aspirant to pure culture, he would perhaps agree with the conclusions of William B. Munro who, in an article entitled "Quack-Doctoring the Colleges"[3] outlines a weary and conflicting list of reforms which are daily urged on our institutions of learning. Dr. Munro says,

> There is no substitute and there never can be any substitute for *men* in the process of education—for earnest, enthusiastic and capable men in the faculty and in the student body. Given these you have a great college; without them, all the new-fangled methods will never avail an institution much. Nearly all the problems of collegiate education merge into two fundamental ones—handpicking the student body and recruiting the faculty. The college that does both things well is on the high road to ultimate distinction; and the one that relegates them to a secondary place in its program, while it goes philandering after mirages, is inexorably headed to the rear of the procession.
>
> It is men, not methods or measures, that determine whether a college shall be first-rate or second class. Or, to put it more accurately, first find the men and the methods will take care of themselves. I should like to find some college with the right men and the wrong methods of education. I don't believe there is one.

M. A. C.

[3] *Harper's Magazine*, **940**, 478–82 (Sept., 1928).

QUANTITY, QUALITY, AND ECONOMY IN EDUCATION

We are all aware of numerous problems confronting the present American educational system. According to Dean Wm. F. Russell of Teachers' College,[1] one of the most perplexing of these problems is three-fold—(1) *greater numbers* of pupils must be accommodated, (2) better *quality* of training must be offered, and (3) greater *economy* in all public expenditures must be observed. When we consider that "our nation was founded upon the assumption that all men are created free and equal," it appears only as a natural consequence that the American people have "come to believe that all should have an equal chance" in education. Dean Russell, in discussing the popular demand for *quantity* education, states:

> We desire no leader to be selected on account of his wealth alone, no child to be bound by the accidents of birth; and we hope that the time may soon come when the race of life will be run from an even start with a free field. Franklin and Lincoln are our heroes. "Onward and upward" is a favorite motto. The most gratifying spectacle to most of us is that of the poor boy rising to the gilded heights. The humble origins of Smith and Hoover are political capital. This is the explanation of the growth of our school system and forms the underlying cause of the extraordinary expansion of all its parts. The public school is dear to the hearts of the American people. Through it they hope to realize their fondest desires; and they will not rest content until every

[1] Report of the Dean (for the academic year ending June 30, 1928), Teachers' College, *Teachers' College Bulletin*, 20th series, No. 1 (Nov., 1928).

boy and girl is given opportunity commensurate with ability, regardless of birth, wealth, or health. Americans want more education.

Intimately connected with this demand for *more* education is that for *better quality* of education. On reading farther, we find that general dissatisfaction with the schools as they are exists among the American people.

Returning travelers receive thoughtful attention when they pronounce American education as inferior to European. Merchants and manufacturers complain of the deficiencies of the graduates of our schools. Famous critics perceive a lack of thoroughness, they detect a certain softness in our teaching; and they plead for the production of true scholars and a return to scholarly ideals. Legislatures enact laws requiring higher standards and better teachers. School authorities advance admission requirements and restrict attendance. Certain colleges practically elect to membership a favored few. Waiting lists are long. Institutions secure popular support by announcing as their aim education of fine quality, and they point with pride to small classes, individual instruction, and education by conference under a tutorial system.

We cannot consider methods of solving the problems outlined above, without investigating the validity of the statements of those experts who claim "the United States cannot afford to support its present educational program." Dean Russell continues:

This seems absurd, but one may well pause when he looks into the future. If the American people proceed with a policy of extending education widely and at the same time increase expenditures in order to work for quality, the time may be not far distant when we shall be forced to consider whether we, as a nation, can afford to pay for all that we want. It is to be hoped that our economists will address themselves to this problem. A portion of the people by their own labors are able to support the balance who are not at work—the young, the aged, the ill, the unemployed, and those who are in school. The ratio of the productive to the unproductive depends upon a variety of factors, among them being wealth of natural resources, geographical location, climatic conditions, length of the working day, week, and year, degree of productivity, economy, and thrift, amount of unemployment, age of retirement, birth and death rates, ratio of children to adults, general health conditions, and the effect of the educational system upon such of these as are modifiable. Thus the early age of retirement in France, the low productivity of China, the frequent holidays of Spain, and the extravagance of the United States, considered by themselves alone, would be conditions tending to limit the educational program; while on the other hand, the thrift of Holland, the long hours of labor of Germany, and the high degree of productivity of the United States, considered by themselves alone, would have the opposite effect. From the weighing and interlocking of these factors will come in time the answer to the question of how good and how extended an educational system a country can have. It seems reasonable to believe that in general we can pay for our present program—and with a more equitable distribution of the burden we can probably afford a more extended one; but the time will surely come when the limit will be reached and beyond that we dare not go.

To sum up, then, this three-fold problem of present-day education, which is as difficult as it is important:

Those who favor quantity are extending educational facilities and welcoming the hordes of students who flock to the doors of our schools and colleges. Those who think first of quality are restricting attendance in order to do their best for small numbers. If it were possible to give a satisfactory education to large numbers in big institutions under conditions of reasonable economy, the results would be of utmost importance. After all, it is a question of the possibility of quantity production of quality in education.

We are warned that there is nothing new in this idea and to substantiate this statement, we quote:

Long ago the leading countries of the world embarked upon such a program. Once the typical educational relationship was a teacher and one pupil at a time; and even in the present day, when one considers the teachers in the old-style schools in Confucian, Buddhist, and Mahometan countries, masters with apprentices, and the adults who are the teachers among primitive peoples, it is probable that there are more teachers in the world teaching one pupil at a time than there are teachers teaching more than one. Until relatively recent times, the educational process was looked upon much as we view tutoring. In the days when the mass of the people received no schooling, when a few were chosen to receive the rudiments of knowledge, and only the children of the nobility were to be educated, it was possible to find and support tutors in quantity sufficient for the task.

As civilization progressed, however, there arose a popular demand for the education of the masses. This necessitated the abandonment of individual instruction.

Various experiments were made. Individuals otherwise employed were pressed into service, assuming teaching in addition to other occupations by which they made their living. Thus priests and pastors, dames, and housewives were placed in charge of schools. Bell and Lancaster devised plans whereby one could teach hundreds; but the class in a school under the direction of a person whose prime function it was to teach proved to be the most successful and economical solution to this problem and as such has persisted to the present day. Group instruction is an effort toward quantity production.

The more important problems of quantity in the schools are stated as follows:

Class work has often been criticized adversely. There has been much discussion concerning proper limits of effectiveness, upper and lower extremes, and the optimum size of the group to be taught. Recent research is giving encouragement to the adherents of the tutorial system. Careful studies of the exact way in which children learn to read, to spell, to add and subtract, reveal that much of it is an individual matter. Class exercises, they say, may serve to help the teacher to diagnose difficulties, to test results, and to give directions; but the learning process is more economical when the individual works alone. This has not forced the abandonment of class work; rather it has called for a new technic of teaching. Educators have found ways so to vary the procedures of class management that individual instruction can be given under school conditions without greatly increased cost. The plan resembles a correspondence course given in residence. Undoubtedly the American genius for administration when turned to this problem will find in the future more perfect methods of supplementing the individual contacts of teacher and pupil so that better results will ensue. It is said that Mark Hopkins on one end of a log and a student on the other would make a university. One wonders why so obvious a statement should be handed down from generation to generation. Naturally it would be a fine institution and the annual tuition charges

per student would be exactly the salary of a distinguished man like President Hopkins. The real problem is so to arrange the logs like the spokes of a wheel that a Mark Hopkins may sit at the hub and pupils and students on the rim in numbers sufficient to carry the cost with economy. Our public schools are progressing toward a solution.

Similarly, there are numerous problems of quality in the colleges to be solved.

Once when the colleges were small there were intimate relations between students and faculty. Students were few. Famous teachers surrounded by their books gave individual attention to a small group. Research was attacked together; interpretation was made incidentally; great scholars were the inspiration; great scholars were the result. As a general thing these times are past. Now the colleges have thousands of students, huge buildings, multiplicity of offerings, and a variety of departments. Professors mourn the days that are gone and the temptation is to try to bring back former conditions. But the commitments are here. Students make their demands. Sheer numbers force a change. In occasional subjects, such as anthropology or astronomy, the old methods are still possible, but for most subjects they are out of the question. The conference becomes a lecture course. What was formerly personal advice is now a printed syllabus. Some of the research guidance is given in a class; and the library, formerly the workroom, the meeting room, the research laboratory, and the classroom, tends to become a collection of books housed in a separate building, upon the campus to be sure, but in no sense holding the intimate and integral relation to the life of the institution that once it held. The colleges are not remaining static. Despite the fact that some are strictly limiting attendance, there are many that are trying to improve their methods the better to adjust themselves for numbers. There is no part of our educational system in which so many changes are being made and so many new ideas being introduced.

Thus we find that, in response to the demand that many be educated, the school and college are already making efforts toward quantity production. Modifications in procedures are being made so as to educate the many better.

By giving quality in quantity they are serving the interests of economy; but the persistent demands for extended facilities, the criticism of American standards, and the call for reduced expenditures indicate that the problem is not yet solved and that much remains to be done.

The remainder of the report quoted above deals with a clear explanation of the methods Teachers' College is using to solve the problem outlined—quantity, quality, and economy in education. In answer to the question—Is quantity production of quality possible in education?—we quote Dean Russell's concluding paragraph:

No one can surely say, but we believe that Teachers College is pointing the way toward an affirmative answer. There is no reason why it cannot be possible, if to the advantages of the large institution can be added the effectiveness of the small. In Teachers College we have been able to maintain that friendly contact with the professor that was found when students were few. Our laboratories and facilities for work in the practical field, while far from perfect, have kept pace with increasing numbers.

We hope to continue to improve these close relations, to better the association of student with student, and in an important way to develop the library. If, in the face of increasing numbers, we can continue to provide these intimate contacts with the sources of training, usually found only in the small college, and at the same time have the high standard of personnel, the rich facilities, and the economical unit costs of the large university, we shall play an important part in the realization of the dream of the builders of our nation—that every child shall have a chance, that all shall have an opportunity. By solving this problem we may be able to help America to provide quality education in quantity at a price within the economic limit of the ability of our people to pay.

M. W. G.

UNITED STATES CIVIL-SERVICE EXAMINATION

The United States Civil-Service Commission announces an open competitive examination for Junior Chemical Engineer, $2000.

Applications must be on file with the Civil-Service Commission at Washington, D. C., not later than January 22nd.

The examination is to fill vacancies in various branches of the service throughout the United States.

The duties are to perform routine testing, inspection of engineering material, drawing up plans for minor projects, preparing specifications for engineering material or apparatus, performing field work, making computations, preparing maps, assisting in conduct of experimental research tests, compiling reports, and handling technical correspondence.

Competitors will be rated on general physics, mathematics, general engineering, and chemical engineering.

Senior students will be admitted to the examination.

Full information may be obtained from the United States Civil-Service Commission, Washington, D. C., or from the secretary of the United States Civil-Service Board of Examiners at the post office or customhouse in any city.

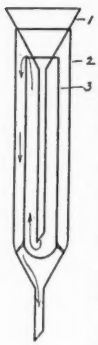
Safety Film of Institute of Makers of Explosives. In connection with the campaign to reduce the number of accidents to children from playing with blasting caps, the Institute of Makers of Explosives has prepared a one-reel motion picture film entitled, "How Jimmy Won the Game." This film shows forcefully and in a way which can be understood by the children the dangers of a blasting cap as a plaything. It is based on a story of a baseball game in a small town. This film is being offered to schools and safety meetings. Copies of it can be had free by addressing C. Stewart Comeaux, Secretary, Institute of Makers of Explosives, 103 Park Avenue, New York City. It is printed on safety stock and therefore can be shown anywhere.

In a survey recently conducted by the Institute, it was shown that there are approximately 500 children blinded or injured each year as a result of playing with blasting caps. Most of these accidents occur in rural districts and are due in every case to the carelessness of adults, who leave these objects about where they can be found by the children.—*Science Service*

ABSTRACTS

TEACHING METHODS, AIDS, APPARATUS, AND SUGGESTIONS

Squaring the Ends of Glass Tubing. G. N. QUAM. *Chem. Analyst*, No. **49**, 12 (Feb.-Mar., 1927).—"When a glass tube breaks in an irregular manner when cutting it or when the ends become jagged, the squaring up can be accomplished by the following scheme with the least danger of causing further irregular fractures. The tube is held firmly in one hand near the end to be squared-up and is rubbed briskly with a wire gauze (iron) across the end of the tube with a motion away from the person. If the tube is very hard and tough it is usually necessary to strike it with the gauze in order to wear down the jagged edge. Shattered ends of combustion tubes, condenser tubes, and the like can very easily be trimmed in this manner. The effect of the wire gauze seems to be that of a series of flexible files. The writer has found this method to be very effective with glass tubing ranging in size from ordinary $^3/_{16}$" up to 1" outside diameter." M. W. G.

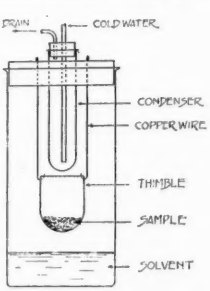


A Constant Flow Filter-Funnel. CHARLES B. DAVIS. *Chem. Analyst*, No. **49**, 13 (Feb.-Mch., 1927).—The accompanying cut shows the assembled filter-funnel recommended. The funnel (1) rests on the outer tube (2) with the stem reaching to the bottom of the tube (3). The tube (3) may be unattached, or sealed to the outer tube (2) or held by a rubber adjunct.

In assembling, it is expedient that the stem of the funnel be free from contact with the bowl of the reservoir. Either a Buchner or sugar funnel with Gooch crucible and rubber ring may be substituted for the ordinary funnel. The outer tube should have sufficient diameter to permit the constant flow and at the same time prevent the siphoning of the liquid from the reservoir.

Advantages claimed are: (1) because of the constant flow produced and maintained through the introduction of a stabilizing reservoir, this filter-funnel, so called, obviates the necessity for exactness in the construction of the cone, in fact, that the paper adheres closely to the cone is secondary in obtaining the required results; (2) the reservoir serves a two-fold purpose in entrapping any and all particles which escape the filter paper; (3) the three parts are easily cleaned and readily assembled; (4) the filter-funnel is also adaptable to double filtration. M. W. G.

An Improved Extraction Apparatus. F. E. BOLTON. *Chem. Analyst*, No. **49**, 15 (Feb.-Mar., 1927).—"A tall, wide-mouthed flask—a wide-mouthed liter bottle might be used for low-boiling solvents—is fitted with the condenser shown in the sketch. This condenser is made from a large test tube or freezing-point tube carrying a two-hole rubber stopper with an entrance tube extending to the bottom and an exit tube just clearing the bottom of the stopper. Through the stopper holding the condenser in the mouth of the flask are run two stout copper wires, anchored at the top and bent into hooks at the bottom for the purpose of holding a thimble in which the sample is placed. A very small notch is cut in the edge of the stopper to act as a vent for the prevention of pressure in the flask. When heat is applied to the bottom of the flask containing the solvent, the vapors rise, are condensed on the cold test tube, and drip into the thimble and through the sample. Once the flame is properly adjusted, the apparatus will run indefinitely without attention. There is practically no loss of solvent. A paraffined cork is preferable to a rubber stopper for holding the condenser, since it permits the use of solvents which would act on rubber." M. W. G.



A Constant Temperature Bath. *Synthetic Org. Chemicals*, **2**, 3 (Oct., 1928).—"The organic chemist frequently has occasion for a constant temperature bath, accurate within a few tenths of a degree, which can be readily installed and as readily replaced on the shelf when it has served its purpose. Such an apparatus must be of simple and rugged construction and afford temperatures over a wide range.

"These conditions, it is believed, are met by the device here depicted (Figure 1), consisting of a bath surrounded by the vapor of a definite liquid or constant boiling

mixture of liquids. Small sizes may readily be constructed from copper glue-pots, by soldering the inner member to the outer, and tubulating the upper portion of the jacket for the attachment of a reflux condenser. Larger sizes, and those required for temperatures above 150°C., are best constructed in a sheet-metal shop of welded black iron plate.

"The bath may consist, for temperatures below 100°, of water covered with a thin layer of lubricating oil to prevent evaporation. For higher temperatures, machine or medicinal oils are suitable. The apparatus, if suitably covered, also forms a convenient air-bath as shown by the accompanying photograph (Figure 2)."

The following suggestions are offered for liquids in the vapor jacket:

35° Ethyl Ether, 42° Methylal, 56° Acetone, 64° Methyl Alcohol, 69° Benzene—Water (azeotropic mixture), 78° Ethyl Alcohol, 84° Ethylene Chloride, 92° Butyl Alcohol-Water (azeotropic mixture), 100° Water, 110° Toluene, 116° Butyl Alcohol, 126° Butyl Acetate, 132° Chlorobenzene, 139° Iso-Amyl Acetate, 157° Bromobenzene, 165° Butyl Butyrate, 175° Cymene, 183° Aniline, 193° Dimethylaniline, 206° Tetrahydronaphthalene.

G. B. C.

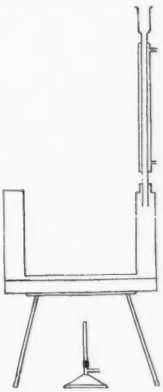


FIGURE 1

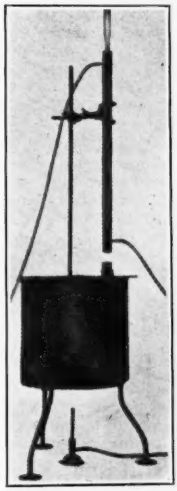
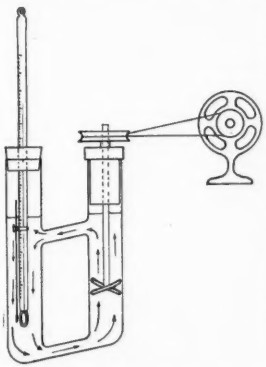


FIGURE 2

A Mechanical Agitator. G. N. QUAM. *Ind. Eng. Chem.*, **20,** 908 (Sept., 1928).—An agitator, with diagram, devised for determining the relative rates of corrosion of metals exposed to common food products is described. The application of this device could be extended to other problems. M. W. G.



Apparatus for Determining Melting Points. S. AVERY. *Ind. Eng. Chem.*, **20,** 570 (June, 1928).—"The tube is essentially a Thiele tube, lengthened for the use of an Anschütz total-immersion thermometer and modified to permit mechanical circulation by means of a propeller. The fluid is liquid petrolatum or glycerol. If sulfuric acid is to be used, the propeller and shaft should be of glass and the bearing in which the shaft turns should be of lead. The propeller may be constructed with arms, or in the form of a spiral. The bearing should fit the tube fairly closely. The shaft is driven by a small fan motor at about half the motor's maximum speed.

"The tube is heated in the same manner as the Thiele tube, but less care is required than in an apparatus depending upon gravity for circulation. The temperature of the liquid can be regulated with great precision. The tendency of the thermometer to fluctuate, when the tube is heated slowly, is avoided."

M. W. G.

The Fluorescence Microscope. FRANK E. CHALLIS. *Trans. Ill. St. Acad. Sci.*, **20,** 181–3 (Mar., 1928).—The apparatus consists of an arc lamp provided with a suitable condensing system, a series of filters, and the microscope. Light waves of the spectrum are removed by passing the light through copper sulfate solution, ultra-violet glass, and *p*-nitroso dimethyl aniline. The stage below the microscope is equipped with a total reflecting prism of quartz and Abbé condenser of the same material. Quartz microscope slides are also used in these experiments.

Objectives and eye piece of the microscope are of the ordinary glass system as we are dealing here with visible radiations. A plate of uranium glass is placed above the quartz prism to show when illuminant on the optical system is in alignment, the uranium glass becoming brilliant when the beam of light is thrown upon it. It is then removed

from the prism and placed above the Abbé condenser when a brilliant spot of light should appear over the center of the condenser.

The substance to be examined is now mounted on the quartz slide and placed on the stage of the microscope where if it has any fluorescent properties, it will become luminous.

The purposes of the microscope are two: (*a*) substances not usually considered fluorescent may contain minute quantities of fluorescent materials that are too small to be seen with the naked eye but are revealed by the microscope; (*b*) many ores are composed of a variety of chemical substances. When these are subjected to ultra-violet radiation, the entire mass will fluoresce a single color, but examined under the microscope they may be resolved into a number of different colors, each color coming from a different substance. Minute quantities of impurities can be detected by this method.

The number of substances fluorescing in ultra-violet light is very great and they are found in every line of research. Much work will have to be done before definite statements are made of the practical application of this type of microscope. R. M. P.

The Oxalate Method for Determining Calcium and Magnesium. WILLIAM T. HALL. *J. Am. Chem. Soc.*, **50**, 2704–7 (Oct., 1928).—The authors give a concise review of many of the more important contributions to the literature dealing with the separation of calcium and magnesium by the above method. They note contradictory statements concerning the amount of ammonium oxalate which should be used when magnesium is present in large and small amounts. In order to check the procedures commonly used and determine the validity of certain of the statements which have been made, the author here reports conclusions drawn from a great many analyses of pure salt solutions containing varying proportions of the two metals. He finds that a considerable excess of ammonium oxalate should be present and that even a very considerable excess does not precipitate magnesium oxalate, as has been claimed. He does find, however, that a large excess of ammonium oxalate serves to prevent the subsequent complete precipitation of magnesium as the magnesium ammonium phosphate. He concludes that 75 cc. of 0.5 *N* ammonium oxalate is sufficient to precipitate 300 mg. of calcium ion in a volume of 500 cc. but that identically the same amount should be used for only 20 mg. of calcium ion if considerable magnesium is present. A. P. B.

Teaching from the Blackboard. GARRY CLEVELAND MYERS. *High Sch. Teacher*, **4**, 267, 285 (Sept., 1928).—In brief the author suggests: "Use the blackboard for correct teaching and not for that upon which pupils exhibit mistakes." Teachers should choose good models, place them upon the board and leave them there as long as they are useful to the students. Such models should be so carefully drawn or lettered as to be attractive. Excellent board exhibits will become guideposts for the pupil trying to direct himself. B. C. H.

Specific Study Helps in Exact Science. A. W. CRONK. *Mich. Educ. J.*, **6**, 115 (Oct., 1928).—Students do poor work because they do not know how to study effectively. Every high school accredited by the University of Michigan is expected to follow some definite plan for training pupils in effective habits of study. The Hutchins Intermediate School in Detroit makes use of the following plan. Study helps, as given below, are printed on gummed paper and distributed to the pupils to be pasted in their texts. One or more class periods are spent by the teacher explaining the study helps and teaching the pupils to apply them to their work. A sample of the special helps for general science is as follows.

BEFORE CLASS. Do you watch the newspapers and other periodicals for pictures, clippings, and current science reports? Do you use the science books in the library for references and reports? Do you observe and make collections of things in nature? Do you interview people in the business world? Do you see that your pencils are well sharpened; that you have filler for your notebook as well as other necessary materials?

IN CLASS. Do you plan the hour after the assignment has been made? Do you take notes when the assignment is made? After the monitors have passed the materials, do you start to work? Do you keep a notebook to which you may refer in time of doubt? Do you always follow the usual procedure of your class in writing experiments? Do you work alone or in coöperation with your group on all assignments? When you find a hard word do you use the dictionary? Do you read your texts, look up your topic in other books, and tell the class what you have found? Do you use your index, appendix notes, review questions, diagrams, and photographs in your books so as to learn the most about your subject? Do you review your science notes? Do you use the scientific method in your investigations?

AFTER CLASS. Do you apply the principles of science which you have learned in the classroom in your daily life? E. R. W.

List of Books Recommended for High-School Chemistry Library. *Neo-Chemto-*

Ion, **3,** 10 (Sept., 1928).—*Snapshots of Science*, E. E. Slosson; The Century Company, 2126 Prairie Ave., Chicago, Ill. *American Inquisitors*, Walter Lippman, Barbour-Page Lectures, University of Virginia, Charlottesville; The Macmillan Company, Prairie Ave. and 25th St., Chicago, Ill. *Organic Chemistry*, Rice; McGraw-Hill Book Co., 370 Seventh Ave., New York City. *Stars and Atoms*, Eddington; Yale University Press, New Haven, Conn. *Investigations in the Teaching of Science*, Curtis; P. Blakiston's Son & Company, 1012 Walnut St., Philadelphia, Pa. *Dictionary of Applied Chemistry* (seven volumes), Thorpe; Longmans, Green and Company, 221 E. 20th St., Chicago, Ill. *The Story of Chemistry*, Darrow; Bobbs-Merrill Company, 18 E. Vernon St., Indianapolis, Ind. *Chemistry in the Home*, Howe and Turner; Scribner's Sons, 5th Ave. and 48th St., New York City. *The Romance of the Atom*, Harrow; Horace Liveright, New York City. *Book of Popular Science*, 15 volumes; Grolier Society, New York City. *Compton's Pictured Encyclopedia*, 15 volumes; Compton's Publishing Co., Chicago, Ill. M. W. G.

KEEPING UP WITH CHEMISTRY

Adhesive Action. EDITORIAL. *Silicate P's & Q's*, **8,** 1–2 (Oct., 1928).—The few known simple elements of adhesive action are given as: the adhesive must wet the surface; penetrate to the right degree; change from a liquid condition to a solid or a semi-solid when it sets; and have flowing characteristics (or "body"), which depend in a large measure upon viscosity. This article is illustrated by photographs showing the behavior of silicate adhesives of different viscosities upon asbestos paper. B. C. H.

Preservative Regulations in Germany. H. ZELLNER. *Analyst*, **53,** 541 (Oct., 1928).—Dr. H. Zellner, Public Analyst, Berlin, informs us that the following regulations as to the use of preservatives in Germany have been in force since October 1, 1927:

Article of Food	Preservative	Gm. Maximum allowed per 100 g. of article of food	Declaration of preservative content
1. Meat salad	Benzoic acid	0.125	No
2. Fish preserves (anchovy)	Boric acid	0.5	Yes
3. Caviare	Hexamethylenetetramine	0.1	Yes
4. Crabs, fresh	Boric acid	0.9	Yes
Crabs, preserved		0.75 (0.9)	
5. Preserved eggs, yolk for exclusive consumption in bakeries or for manufacture of macaroni	Boric acid	1.5	No
Yolk	Benzoic acid	1.0	No
6. Edible fats, margarine	Benzoic acid	0.2	No
7. Mayonnaise	Benzoic acid	0.25	No
8. Grits and groats	Sulfurous acid	0.044	No
9. Preserved fruit, dried fruit	Sulfurous acid	0.125	No
Fruit juice	Benzoic acid	0.15	No
Fruit juice	Formic acid	0.25	No
Fruit pulp	Benzoic acid	0.15	No
Fruit pulp	Formic acid	0.25	No
10. Wine	Sulfurous acid in gaseous form or its solution in distilled water, and technically pure potassium metasulfite containing at least 5 per cent SO_2	Provided that only small quantities of sulfuric acid are contained in the beverage	No
11. Imported wine	Sulfurous acid in gaseous form or its solution in distilled water, and technically pure potassium metasulfite containing at least 5 per cent SO_2	According to the regulations for the sale in the countries of origin	No
12. Edible gelatin	Sulfurous acid	0.125	No

M. W. G.

High Temperatures Recorded in Uncle Sam's Test Fires. G. F. DACY. *Tycos*, **18,** 132 (Oct., 1928).—"Start scientific fires and study them if you wish to solve the secrets of such holocausts" is the slogan of the National Bureau of Standards. This is exactly what is being done by the government engineers. From the man-started fires they obtain the highest temperature developed, the time required for the flame to reach its peak intensity, the hottest portions of the burning building, the relation between design of the building and fire security, the manner in which the building falls, the relation between temperature and number of pounds of combustibles per unit area, and the maximum temperatures obtained in strong boxes.

The methods of carrying out these investigations are given. The story of the scientific burning of some of Uncle Sam's buildings in the heart of Washington is also included. E. L. M.

Sodium Alum. H. LEFFMANN AND L. W. STROCK. *Catalyst*, **13,** 10–1, 15 (June-July, 1928); (reprinted from *The Bull.*, Wagner Free Institute of Science, 1928).—The derivation and application of the term alum are discussed.

Difficulty of crystallization of the sodium alum seems to have barred this substance from trade in general. Various studies of the properties of sodium alum are summarized and experiments of the authors leading to the production of definite crystals are described. D. C. L.

A Curious Case of Antimony Poisoning. J. T. DUNN. *Analyst*, **53,** 532–3 (Oct., 1928).—Persons drinking lemonade stored over night in covered enameled buckets became suddenly sick. Investigation led to the discovery that the lemonade contained antimony compounds, expressed as metallic antimony, amounting to 0.013%. Analyses showed that the enamel coating on the buckets contained the offending element. M. W. G.

Patents and the Chemist. A. B. MOULTON. *Catalyst*, **13,** 8 (June-July, 1928).—The attention of chemist's interested in the subject of patents is drawn to Section 4886 of the revised statutes of the U. S., which is quoted and explained. D. C. L.

Experimental Researches upon the Diffusion of Hydrogen through Nickel. VICTOR LOMBARD. *J. Chim. Phys.*, **25,** 501–30 (July, 1928).—A rather exhaustive resumé of work that has been done upon diffusion of gases through metals. B. C. H.

Indiana's Great Limestone Industry. R. G. SKERRETT. *Compressed Air Mag.*, **33,** 2539–46 (Oct., 1928).—An interesting, well-illustrated, description of the limestone quarries of the Bedford-Bloomington district. The article contains a brief geological explanation of the formation of these deposits as well as a history of their commercial development. From a very modest beginning in 1840 their importance has increased to such a magnitude that now 35% of all the rough and finished building stone used in the United States comes from this district. E. R. W.

Practical Digest of the Year's Work in Photography. E. J. WALL. *Am. Annual of Phot.*, **42,** 187–97 (1928); *C. A.*, **22,** 3593 (Oct. 10, 1928).—In the review of progress in photography, the following subjects are covered: phototheory and emulsions, amateur cinematography, development and fixation, optical and color sensitizing, after-treatment methods, motion picture work, special processes (bromoil, carbro, etc.), photolithography and color photography. M. W. G.

The History of Staining: Cochineal Dyes. H. J. CONN AND S. I. KORNHAUSER. *Stain Tech.*, **3,** 111–21 (Oct., 1928).—Cochineal dyes have played an extremely important part in the history of staining. Before the discovery of aniline dyes, carmin was the only stain available that was satisfactory for histological purposes. The impetus given to its use in these early days would have assured it a place in the histological laboratory for many years after the introduction of aniline dyes, even had it proved decidedly inferior to these newer products. As a matter of fact, the cochineal dyes have proved so well adapted to certain special purposes that no artificial dye yet known promises to replace them. For bulk staining, or for staining embryos *in toto*, carmin is second to none, while the wide range of formulas available calling for cochineal, carmin, or carminic acid, makes possible their adaptation to a long list of histological and cytological purposes. A certain amount of experience in their use is necessary; and many failures to secure good results have been due to the method of fixation of the tissues. Thus tissues fixed in formalin, in chromic or osmic acids stain poorly with carmin; while fixation with picric acid or bichloride of mercury allows this dye to stain splendidly. The dye is, moreover, difficult to secure in uniform quality, thanks to the fact that it is not synthetically prepared. Yet with all its disadvantages, it is one of the extremely valuable stains; and although the first dye to be employed by the microscopist, it becomes increasingly evident that neither carmin nor the other cochineal products are yet ready to be put in the discard. M. W. G.

The Iron and Steel Industry of Ohio. M. V. MCGILL. *Neo-Chemto-Ion*, **3**, 2–6 (Sept., 1928).—The early history of the iron and steel industry in Ohio is sketched. Various methods of making steel with advantages and disadvantages of each are described. A table showing operation and production for the chief steel centers of Ohio, and an easily interpreted map of Ohio, showing the centers of steel industry, are included. Ohio, since 1904, has been the geographic center of steel manufacturing activity of the U. S. M. W. G.

The Radium Mines at Jachymov. ANON. *Chem. News*, **137**, 226–7 (Oct. 12, 1928).—A short review of the history of the working of these mines. Two illustrations. M. W. G.

The Outlook for Plastics. J. N. TAYLOR. *Chem. News*, **137**, 228–30 (Oct. 12, 1928).—A brief review, with statistics, of the growth of the plastic industry in America. The topics discussed are: bulk of production and trade in materials manufactured from pyroxylin; the pyroxylin industry; shipments to foreign countries; and synthetic resins industry, with notes on its American development. M. W. G.

Butanol Fermentation Process. C. L. GABRIEL. *Ind. Eng. Chem.*, **20**, 1063–7 (Oct., 1928).—Contains an account of the history and development of the fermentation process for butanol and acetone. M. W. G.

Methanol from Hydrogen and Carbon Monoxide. R. L. BROWN AND A. E. GALLOWAY. *Ind. Eng. Chem.*, **20**, 960–6 (Sept., 1928).—"The production of methanol from carbon monoxide and hydrogen under pressure has been studied comparatively with zinc oxide, basic zinc chromate, and normal zinc chromate as catalysts. The last two catalysts are more active than the zinc oxide, and at higher pressures and temperatures the normal chromate proved to be the more active of the three. It is a hardy catalyst. At 400°C. and 180 atmospheres, and in a theoretical mixture of hydrogen and carbon monoxide, an experimental conversion of the latter to methanol of about 20 per cent has been attained." M. W. G.

Industrial Applications of the Electric Furnace. H. H. WATSON. *Tech. Eng. News, Mass. Inst. Tech.*, **9**, 206–8, 216–24 (Oct., 1928).—There is presented a brief historical statement of the introduction of the electric furnace into industrial processes and a discussion of its operations and commercial advantages in the iron and steel industry. The drawings showing electric furnace classifications are illuminating. L. W. M.

Application of Oxygen and Hydrogen to Industrial Operations. Part VI. Hydrogen, Nitrogen, and the Electric Furnace. F. P. WILSON, JR. *Gen. Electric Rev.*, **31**, 493 (Sept., 1928).—A brief description is given of some of the features that must be considered in using hydrogen and hydrogen-nitrogen mixtures in electric furnaces.

The above-mentioned atmospheres are used not for the purpose of heat but to furnish a non-oxidizing atmosphere which is desired in the processes of electric brazing and annealing.

The following phases are discussed: design; installation and operation of furnace; factors involved in combustion, explosion and detonation; preparation of hydrogen and hydrogen-nitrogen atmospheres; effects of diluents on reactive mixtures; factors favoring success in the use of hydrogen and hydrogen-nitrogen atmospheres in electric brazing and annealing furnaces. E. L. M.

New Indicating Equipment for Industrial pH Measurements. H. C. PARKER. *Ind. Eng. Chem.*, **20**, 676–80 (July, 1928).—Three new potentiometers are described with illustrations. Two of these have scales which are direct-reading in pH. The technic required for making measurements with industrial types of quinhydrone electrode and the relative suitability of H-ions and conductivity measurements are discussed. M. W. G.

An American Impression of I. G. Plants. C. E. MULLIN. *Chem. Age*, **19**, 336 (Oct. 13, 1928).—An account of the author's experiences on a recent visit to the dyestuff and allied works of the I. G. Plants. The plants reported on are: The Baeyer Co. at Leverkusen; the M. L. B. Plant at Hoechst; the Naphthol Plant at Offenbach; and the Badische Plant at Ludwigshafen. M. W. G.

Economic Symposium on Nitrogen. *Ind. Eng. Chem.*, **20**, 1128–47 (Nov., 1928).—The papers included under this title were presented before the Division of Industrial and Engineering Chemistry at the 76th Meeting of the American Chemical Society, Swampscott, Mass., September 10–14, 1928. The purpose of the symposium is clearly stated by Wm. Haynes, in his introduction to the series of articles.

"We have selected nitrogen as the subject of this first economic conference; first, because the nitrogen problem is timely; second, because of its wide and diverse interests;

and third, because nitrogen furnishes an exceptionally pretty example of the complexities of economic chemistry.

"In as much as nitrogen is a vital and the most costly element of plant food, it is an interesting factor in our farm problem. Since it is an essential element in modern explosives, it is intimately connected with national defense and international politics. We are familiar with the astonishingly rapid technical advancements in nitrogen manufacture and the notable expansion of new chemical uses and new chemical processes employing this element.

"At the present time the world's nitrogen production balances roughly with consumption; but new development programs, now actually under way, indicate that next year we will have a surplus production so great that, in spite of the growing use of nitrogen, consumption will not catch up for several years to come. The obvious economic results of this overproduction is going to be an intensely keen competitive market in which we will have the almost unique example of the three great types of chemical products—a natural product, Chilean; a by-product, ammonium sulfate; and a manufactured product, synthetic nitrogen in various forms—all in direct active competition.

"To discuss these intensely interesting economic problems, we have five outstanding chemical industrialists, each by experience and daily contact preëminently well-fitted to expound his chosen subject."

The titles and authors of the papers are as follows:

"The New Economic Aspects of Nitrogen," J. E. Crane, Lazote, Inc., Wilmington, Del. "Synthetic Ammonia," E. M. Allen, The Mathieson Alkali Works, Inc., New York City. "Economic Relationship between Nitrogen and Fertilizers," H. R. Bates, International Agricultural Corp., Atlanta, Ga. "Economic Status of the By-Product Coking Industry with Reference to the Nitrogen Situation," C. J. Ramsburg, The Koppers Co., Pittsburgh, Pa. "The International Nitrogen Problems," W. S. Landis, American Cyanamid Co., New York City. M. W. G.

Influence of Chemistry on Civilization. Lecture 1—The Chemist at the Breakfast Table. JAMES C. IRVINE. *Ind. Eng. Chem.*, **20,** 884–8 (Sept., 1928).—First of a series of lectures presented at the Institute of Chemistry of the A. C. S., Evanston, Ill., July 24, 1928. This lecture, in the words of the author, "is an attempt to give, in popular fashion, a perspective view of what the science of chemistry has done to influence human activities and to trace the connection between chemistry and world conditions."

It is written with the characteristic Irvine simplicity and contains innumerable valuable suggestions for those interested in the Prize Essay Contest. Typical breakfast-table reflections of a chemist aroused by such commonplace articles as the linen tablecloth, the morning paper, oatmeal porridge, spoon and plate, tea, sugar, bread and butter, burning coals in the fireplace, and the morning pipe are included.

After reading this article we cannot but feel convinced that even the simplest elements of life contain abundant evidence of the interdependence of chemistry and world progress. M. W. G.

On Popularizing Science. WILLARD N. CLUTE. *Trans. Ill. St. Acad. Sci.*, **20,** 25–9 (Mar., 1928).—The thesis is that not enough is being done to popularize science and the study of science. The scientist carrying on investigations rarely has time or opportunity to make his problems intelligible to the general public. In return the public is prone to think that science is the province of the super-individual and quite beyond ordinary comprehension. Though an occasional investigator from the public may be attracted to scientific things the majority do not know where or how to begin. Much as they would like to understand and enjoy they can only wonder and speculate.

The stirring of the scientific instinct may be observed in the collecting of shells, plants, etc. This interest should be directed into useful channels before an enthusiastic student is lost to science for want of somebody to set his feet in the right path.

A wider interest in science will benefit not only the beginner, but a better informed public may be depended upon to aid even the advanced scientist in his work. Practically all advances toward a healthier and happier existence have come through the efforts and discoveries of the scientist, but without support from an intelligent public such advances may be greatly delayed or even frustrated.

It has been said that if the daily press devoted as much space to science as it now devotes to sports, the scientist and all his works would come into their own—but not if the cub reporter conducted the science page. It is perhaps too much to ask that the newspapers will do much for science of their own accord. The subject lacks the spectacular, offers no very definite field for exploitation, and does not contribute to the gate receipts.

The author hesitates in making suggestions as to how the situation may be remedied. He believes scientific meetings go a long way in arousing enthusiasm in the beginner and that possibly some papers should be given designed to attract the non-scientific, though these should not be too elementary. The scientist, no matter what his field, should take the public more into his confidence. He may be obliged to crowd the "science" reporter out of the local papers—or reform him. Propaganda to establish science in its rightful position before the public is necessary.

Working people have been favored with shortened hours of labor and thus an increased number of people have time to take up scientific studies. We should not let the auto, the radio, the movies, and sports engross the entire attention of this new aggregation of prospective investigators. We should bring to the masses a more worthy way of spending their leisure, to give them a deeper appreciation of the world we live in, and by advancing science promote a safer, saner, and more satisfactory existence.

R. M. P.

The George Herbert Jones Laboratory at the University of Chicago. H. I. SCHLESINGER. *Chem. Bull.*, **15,** 251–3 (Sept., 1928).—The building, an addition to Kent Chemical Laboratory, will be devoted almost exclusively to graduate and research students. But one undergraduate chemistry course, elementary physical chemistry will be given in the building. Undergraduate courses will be offered in Kent. That structure, in its basement, will also house the stores and service features for the department.

The new building will provide for elementary and graduate physical chemistry upon its first floor; the library and seminar room on the second; graduate laboratories for organic chemistry on the third; and for advanced inorganic chemistry on the fourth.

The major portion of the building, however, is dedicated to research activities. This is served by twenty-one two-man rooms; seventeen one-man rooms and nine four-man rooms. This space accommodates approximately one hundred research students. The laboratories for courses will take care of three hundred additional students.

Architecturally, the building will harmonize with others upon the University quadrangle.

B. C. H.

The Life Work of Justus von Liebig. PAUL KRISCHE. *Ernàhr. Pflanze*, **24,** 154–62 (1928); *C. A.*, **22,** 3811 (Oct. 20, 1928).—With portrait and 11 other illustrations.

M. W. G.

Hendrik Antoon Lorentz. MAX PLANK. *Naturwissenschaften*, **16,** 549–55 (1928); *C. A.* **22,** 3811 (Oct. 20, 1928).—A memorial lecture with portrait. M. W. G.

Great Chemists and the Development of Chemistry. J. G. F. DRUCE. *Chem. News*, **137,** 245–6 (Oct. 19, 1928).—Two recent books—*The Great Chemists*, by E. J. Holmyard (Methuen and Co., London) and *La Chimie d'Hier et d'Aujourd'hui* by A. Kirrmann (Gauthier-Villiers, Paris)—are briefly reviewed. The former traces the history of chemistry from antiquity to the present time, stressing the personalities of the outstanding contributors to the science. The latter, while covering the same ground, deals mainly with the discoveries, facts and theories, emphasizing the historical development of the various branches of chemistry. M. W. G.

Chemistry and the American Chemical Society. S. W. PARR. *Ind. Eng. Chem.*, **20,** 994–7 (Oct., 1928).—The presidential address delivered at the 76th Meeting of the A. C. S., Swampscott, Mass., Sept. 10–14, 1928. M. W. G.

EDUCATIONAL MEASUREMENTS AND DATA

Minor Studies on Objective Examination Methods. I. The Negative Suggestion Effect of True-False Tests. HAZEL M. ROBERTS AND G. M. RUCH. *J. Educ. Res.*, **18,** 112–6 (Sept., 1928).—Criticism of true-false tests have been made to the effect that false statements presented to pupils in these tests leave residues of misinformation that are far from desirable in constructive education. The authors conducted experiments upon classes in botany and in chemistry. Their summary states that: (1) the negative suggestion effect exists; (2) it is much smaller than many critics believe; (3) the *net* suggestion effect of a true-false test appears to be positive, not negative; (4) this positive effect does not eliminate the entire force of the objection to true-false tests; (5) negative and positive suggestion effects appear to be transitory, and it seems within reason that an interval of one or two school semesters might wipe out such effects completely.

R. M. P.

Chemistry Teaching in Nebraska. B. CLIFFORD HENDRICKS AND JOHN S. CHAMBERS. *Nebr. Educ. J.*, **8,** 381 (Sept., 1928).—The paper is not of historical nature but is rather an attempt to make the results of an investigation a matter of record. The

work was carried out under the direction of the committee of chemical education of the American Chemical Society.

The source of data is given and the following aspects of the investigation are reported: the generality of the study of high-school chemistry; the cost of instruction per school and per student; the course followed; the qualifications of the teachers; the reasons for high-school chemistry's limited study; the number of high-school students who take college chemistry; the per cent of college students electing chemistry; the cost of college chemistry; the college chemistry instructional staff; and a summary of methods of teaching chemistry in Nebraska. E. L. M.

Waste in Professional Education. RICHARD E. HYDE. *J. Educ. Res.*, **18,** 144–8 (Sept., 1928).—The study was made of the over-lapping and duplication of subject matter for upper classmen as compared to that for freshmen using as test classes an elementary course in educational psychology and a course in high-school methods. It was found from tests given at the beginning of each course: (1) that all the members of each course displayed some knowledge of the course; (2) that the upper classmen as a whole were more familiar with the instructional content to follow than the freshmen were with their prospective subject matter; (3) certain segments of information were known to almost every one; (4) that each upper classman knew half or more of the true-false statements in his test; (5) that each freshman possessed knowledge of almost one-half of the course. R. M. P.

A Comparison of the Lecture-Demonstration, Group Laboratory Experimentation, and Individual Laboratory Experimentation Methods of Teaching High-School Biology. PALMER O. JOHNSON. *J. Educ. Res.*, **18,** 103–11 (Sept., 1928).—An attempt is made to evaluate different methods of teaching on an objective basis. Progress in methods need not wait upon laboratory schools but much valuable information will accrue if teachers in typical schools will test various methods. In the experiment described there is an attempt to try out under ordinary school conditions the relative efficacy of three different methods of laboratory instruction in three classes of laboratory biology. The study was limited to accomplishments which are capable of quantitative measurement. It consisted of two series of twenty-four experiments, one series being conducted the first semester, the other during the second. Terman Group Intelligence Tests were used. By the rotation plan each section performed eight experiments by each method under experiment.

Tests were all objective in character, the number of points ranging from fifty to two hundred, and the scores were reduced to a percentage basis. Tests to measure retentivity were administered at various intervals.

The demonstration method is shown to excel the others by a small margin, and may be expected to yield, if not larger, at least equal returns in learning when compared with the group or the individual method. This becomes significant in view of the saving in laboratory equipment and in pupils' time. There appears to be a wider deviation among pupils in a class by the individual method than by either of the others. The individual method ranks lowest in this study. If it is to persist it should be required to justify itself on other grounds than have been evaluated in this study.
R. M. P.

THE METHODS AND PHILOSOPHY OF EDUCATION

A Democratic Experiment in Education. W. W. MILLER. *Educ. Outlook*, **80,** 185–8 (June, 1928).—Tells how schools in Hamburg are run by parents and teachers, beginning with a good summary of the history of schools in this ancient Hansa city.

Administration of each school is in the hands of the teaching staff and the Parents' Council. The head master is elected by them from the teachers; he receives no special pay, may resign at any time (to resume teaching), and holds office for a period of three years.

Pupils regulate discipline. Parents volunteer both materials and service. Poor children receive meals. There are many excursions and frequent evening lectures and parties for parents and children.

The curriculum consists of *Gemeinschafts studen*, or community lessons, examples of which are here described. One of the most interesting features is the annual school journey, which may consist of a month's stay on the school farm or a trip to some other city, etc. Expenses are pooled and means are arranged so that no one is left behind by inability to pay.

Measurable results seem to be lacking, but by all accounts those who go on to higher schools are quicker in apprehension, deeper in understanding, and freer in expression than their fellows. Scholars are eager and enthusiastic about their school life.

Praise comes from many sources and wide influence may be expected from such a bold experiment of elemental democracy in schools. S. R. P.

Education: The Next Steps. CYRIL NORWOOD. *J. Educ. & Sch. World*, **60**, 721–4 (Oct., 1928).—Presidential address to the Educational Science Section, British Assoc., Glasgow, Sept. 7, 1928. The general educational situation in England is discussed, present trends in education indicated, and the responsibility and opportunity of the teachers in the next generation pointed out. M. W. G.

Chemical Education in Quebec. ALEX. VACHON. *Can. Chem. & Met.*, **12**, 251–3 (Sept., 1928).—Our Province is very conservative. Students, even when they intend to take up medicine, engineering, or any other profession in which a preliminary scientific education seems more useful than a literary one, first take their classical course. We think the "classical course based on the study of the ancient languages is still the best way of obtaining the highest culture of the mind." He quotes ex-President James of University of Illinois, "I would bet my money on a graduate of a college of liberal arts, who had decided to go into engineering and had never studied it a single hour, rather than on a graduate engineer, without the liberal outlook." Students with preliminary classical training have more trouble than those with preliminary scientific training during the first year, but invariably excel in third and fourth years.

Practically no chemistry and physics are studied during 4 years of high school and first 2 years of college. In the last 2 years of the classical course chemistry of a theoretical rather than of a practical nature is taken up. Most students take up law or medicine rather than chemistry due to a scarcity of positions and the low salaries. Facilities for advanced work in science in Quebec are not very good.

The author advocates the retention of the classical training in the high school so modified that chemistry could be included. D. C. L.

Constructive Tendencies in Education. J. W. CRABTREE. *J. Natl. Educ. Assoc.*, **17**, 219 (Oct., 1928).—Reference is made to the constructive tendency toward unity on the part of those engaged in educational work. Mention was made of the reported attempt of the public utilities service bureaus to use the schools in influencing state and national legislation on the question of ownership in public utilities. There is a steadily decreasing opposition to the movement for a Dept. of Educ. The growing importance of research is emphasized. A. E. C.

The Significance of the Junior College Movement. L. W. SMITH. *Chi. Schs. J.*, **11**, 41–6 (Oct., 1928).—Factors involved in the establishment and progress of the junior college movement are: (1) change in the thought of educators regarding the organization of education; (2) the demand of the American people for a more extensive educational training for their youth; and (3) economic and geographical conditions.

The various forms which the consequent reorganization of the educational system has assumed are discussed. Fundamental principles underlying secondary education are considered. The author concludes by cautioning the reader of the experimental nature of this movement. M. W. G.

Methods of College Teaching. C. R. WISEMAN. *Sch. & Soc.*, **28**, 433–4 (Oct. 6, 1928).—The reactions of 150 students, all registered in education courses in the U. of Minn. and the S. Dakota State College, to certain methods of college instruction are given.

The method of explaining and evaluating rather than the lecture or recitation method, the utilization of reference rather than text material, consideration of main points rather than detailed, oral rather than written presentation of special reports, and final quizzes covering important work as completed, are preferred. K. S. H.

Instruction in Institutions of Higher Learning. C. R. HICKS. *Sch. & Soc.*, **28**, 428–9 (Oct. 6, 1928).—It is unfortunate that so many self-considered good teachers should dictate to the whole profession concerning the teaching methods in institutions of higher learning in this country when they themselves employ methods which are not only old but about which there is nothing unique.

Rather futile, is it not, to attempt to tell an individual, who has had the best training available and has observed and evaluated for several years the methods of the various professors under whom he has been privileged to sit, what methods to employ when he goes out to teach in a college or university? Such a person will naturally discard the stereotyped methods of the ages and develop a system of his own—suited not only to his needs but to those of his students.

The writer doubts the statement that the most productive teaching is done outside the college. On the contrary, he says, " 'sterility' of teaching is by far more characteristic of the grades and high school than of the institutions of higher learning—institutions as yet not dominated by 'scientific' educators." K. S. H.

The New College Degree—Bachelor of Citizenship. J. T. WILLIAMS. *Sch. & Soc.*, **28,** 383–6 (Sept. 29, 1928).—Feeling that scholarship has become cheapened in America through a too generous granting of B.A. and B.S. degrees, the author proposes a plan whereby students not having scholarly inclinations may spend four (or perhaps only three) years at college and receive a degree—Bachelor of Citizenship. These students would take a specialized course, designed primarily to make them good citizens. K. S. H.

The Curse of Examinations. QUOT. FROM THE SPECTATOR. *Sch. & Soc.*, **28,** 399–400 (Sept. 29, 1928).—No adequate alternative having been discovered, examinations still hold sway as a means of determining whether or not one has absorbed the education prescribed for him. It is a rare examination which does not require for its answers crammed up memorized facts, the result unfortunately of students having been encouraged to memorize and not to reason. Ideal would be the examination paper so devised as to require the student to answer from a properly trained intelligence.

Dr. Norwood in an address delivered to the British Assoc. states that there should be two kinds of certificates issued at the end of a high-school career—one to those students who intend to enter a university, and another to those whose formal education ceases at this point. K. S. H.

The Trap of Habit. W. L. BRYAN. *Wash. Educ. J.*, **8,** 10–2 (Sept., 1928).—Men and women should be trained not only for the present conditions but for future conditions which will result from changes. Vocational education is all right but the pupil should be given along with trade education an education in the basic principles. A future engineer should be trained in physics, mechanics, mathematics, and chemistry, otherwise he will not be able to comprehend the engineering of the future. A. E. C.

A New School Year. EDITORIAL. *Chem. Bull.*, **15,** 259 (Sept., 1928).—Research and investigation require time for thought. It is mildly intimated that it would be more conducive to real productive thinking if those doing investigational work did not find it necessary to dissipate their mental freshness by so many routine teaching hours and their added burden of reports and clerical work.

A desirable leader of graduate research is described as "some one who has a real love for sciences, who is a clear, logical thinker and who, above all, knows how to instill into his fellow workers a real enthusiasm for research." B. C. H.

To What Extent Should College Students Pay the Cost of Education? T. ARNETT. *Gen. Mag. & Hist. Chron.*, **31,** 49–57 (Oct., 1928).—This has been given much consideration lately by trustees and administrators of colleges. At a meeting of Brown Alumni last June, Mr. John D. Rockefeller, Jr., gave his opinion that students who could pay should do so, and that financial assistance should be given to those who could not afford to pay. The student is the chief beneficiary of his higher education. This must be considered when apportioning the part the student should bear. Of 149 endowed institutions studied, 69% of these increased their tuition fees (1919–20 to 1926–27). These institutions are classified according to the rates of tuition charged ranging from less than $100 to over $400. From every indication, tuition fees have not reached their maximum and it is evident the opinion that the student should pay an increasing amount of the cost of his education is now quite common. A resolution embodying that principle was unanimously adopted at a conference at the University of Chicago last summer, attended by college presidents and administrative officers.

From some reports there are indications that costs of education per student may vary from $500–$700. It is planned that the student should pay these costs, and that the tuition fee charged every student be identical. Those who cannot pay are to be assisted by adequate loans and scholarship funds. It would be doubtless found that a large number would fall into the class of those receiving loans. Students would pay off these loans during or after college. We shall have made progress if the principle of repaying the actual cost is established even without interest. Students should be expected to exhaust the opportunities of earning as great a part as possible while in college. This plan of students paying the cost of operation is a condition to be reached gradually over a period of years and not to be put into effect immediately.

This article includes a two-page list of suggestions, all of which stress the fact that students should assume the full amount of their indebtedness and pay it in full, either while in college or as soon as convenient after graduation. J. H. G.

Students' Self-Scoring Card. A Review. *Ohio Teacher*, **48,** 457–8 (June, 1928).—Explains a plan whereby the student charts his own progress in each subject on a graph prepared by Professor Carl F. Vogel, Professor of Education and Director of Teacher Training at Capital University, Columbus, Ohio. The record is based on results of

frequent objective tests. Both the individual curve and that of the class median are recorded.

Details of the scheme, its procedure, and values are discussed. S. R. P.

Strategical Periods for the Encouragement of Research Students. S. R. WILLIAMS. *Science*, **68,** 244 (Sept. 14, 1928).—Few students who take up graduate work or should take it up have the financial backing needed. Student assistantships help greatly but do not furnish an environment productive of enthusiasm. More fellowships are suggested.

Some provision should also be made to finance students who are not quite prepared for graduate work either through late orientation or because they attended poorly equipped schools. Special student assistantships are suggested for this purpose. G. H. W.

The Cultivated Man. CHARLES W. ELIOT. *Golden Book Mag.*, **8,** 485–90 (Oct., 1928).—See "This Modern Culture," Chemical Digest, THIS JOURNAL, page 1674. M. W. G.

Quack-Doctoring the Colleges. WM. BENNETT MUNRO. *Harper's*, No. **940,** 478–82 (Sept., 1928).—See "This Modern Culture," Chemical Digest, THIS JOURNAL, page 1674. J. W. H.

Tools for the Intellectual Life. BERNARD DE VOTO. *Harper's*, No. **941,** 602–9 (Oct., 1928).—See "This Modern Culture," Chemical Digest, THIS JOURNAL, page 1674. J. W. H.

Bureaus of Research and Statistics in State Departments of Education. H. B. CHAPMAN. *Educ. Res. Bull.*, **7,** 276–80 (Oct. 3, 1928).—These organizations have been definitely created for the purpose, *first* of exercising functions of reference or investigation, and *second*, of organizing and directing the investigational activities of others.

Numerous problems undertaken and services rendered by various bureaus indicate the possibilities of this current movement in education. M. W. G.

Projects of the Bureau of Educational Research, Ohio State University for 1928–29. *Educ. Res. Bull.*, **7,** 306–10 (Oct. 17, 1928).—Twenty-one projects are outlined. M. W. G.

The N. E. A. at Minneapolis. J. D. MEYER. *Wash. Educ. J.*, **8,** 26–8 (Sept., 1928). A. E. C.

Resolutions Adopted at Minneapolis. RESOLUTIONS COMMITTEE. *J. Nat. Educ. Assoc.*, **17,** 215–8 (Oct., 1928).—Resolutions are headed: (1) Education for a Democracy, (2) National Congress of Parents and Teachers, (3) Financing Education, (4) Retirement, (5) Tenure, (6) The Curriculum, (7) Illiteracy, (8) Americanization, (9) International Relations, (10) Freedom of the Teacher, (11) Convention Attendance, (12) Health and Physical Education, (13) Postage Rates for Books, (14) Unity of Educational Administration, (15) Bureau of Education, (16) The Education Bill, (17) To Minneapolis. A. E. C.

The New Education Bill at Minneapolis. ASSOCIATION'S LEGISLATIVE COMMISSION. *J. Nat. Educ. Assoc.*, **17,** 213 (Oct., 1928).—The bill as reintroduced in the Seventieth Congress contains one important change. Section 10 has been added to provide for a National Council of Education to be composed of the chief school officials of each state and territory. Tribute was paid to the impetus given the Department of Education by President Coolidge. There is need for more careful organization within the teaching profession before definite action can be obtained in Congress, also for wholehearted coöperation by all members of the teaching profession. A. E. C.

THE PHILOSOPHY OF SCIENCE

Research and Chemical Industry. F. H. CARR. *Chem. & Ind.*, **47,** 249T–54T (Sept. 7, 1928).—The address of the retiring president of the Society of Chemical Industry delivered at the New York meeting in 1928. The author discusses the support and financial aid which the British government offers, not only for pure research, but also for promoting industry by chemical research. The need for improvement in the British patent laws, especially as applied to chemical industry, is pointed out. Brief mention is made of the recent advances in the following lines of research; nitrogen fixation, fuels, alcohols, catalysis, vitamin *D*, insulin, thyroxin, chemotherapy. E. R. W.

The Rôle of the Amateur in Scientific Discovery. H. P. GILLETTE. *Nucleus*, **6,** 34, 39–40 (Nov., 1928).—The achievements of amateurs (defined as not professional specialists) fill the history of science. In order to show that this is not due to genius, but to original thinking, general conditions which assist the original thinker are considered. Two of these are: (1) an unbiased attitude, freedom from old theories that

so dominate the mind as to blind it to the truth of new theories; and (2) a research instinct, which leads to the questions why this? why that? why the other thing?

The professional expert is not handicapped so much by his expert knowledge as by his tendency to rest satisfied with what he knows. Supplement such a tendency with an inclination to regard original research work as being beyond their powers, and you have quite a complete explanation of the paucity of discoveries by professional men.

"Two generations ago German teachers of science, particularly chemistry, began to stress training in original research. The results have been so prolific that we may well wonder why American teachers have been so slow in following German practice.

"If it be argued that education is primarily designed for the man who is not an original thinker, but for the average man, then the argument assumes that most men lack an instinct for originality, which is a false premise. Original thinking differs not one whit in principle from what is regarded as unoriginal or ordinary thinking, except in degree of originality. In every case of real thinking a problem presents itself for solution, and calls for the gathering of facts, then systematic classification and inferences as to what they signify. It calls also for the memorizing of many of the facts, so that the mind will have material upon which to work; but so far removed from correct understanding of psychology are most of our teachers that they actually inveigh against loading the memory with details, than which no greater error has ever been made.

"It is a mistake to think that German training in research work is not the kind adapted to the needs of the average man. Our firm conviction is that it is the only kind of mental training that has much merit. And it is because certain amateurs have been trained or have trained themselves in that manner that they are able quickly to solve original problems in fields that are new to them.

"Let it also be noted that it usually requires only a few weeks of intensive reading to master all the theories and facts relating directly to any limited branch of scientific knowledge, and it becomes apparent that an amateur can possess himself of more knowledge about it than most professionals have. Then if the investigator has read widely in science and has remembered much that he has read, he is equipped to attack a problem in that branch of knowledge with excellent chance of successful issue."

M. W. G.

THE TEACHING PROFESSION

Who Is a Good Teacher? FRANCIS LEROY COPPER. *Educ.*, **49**, 111–7 (Oct., 1928).—The question is approached in three ways. (1) Analysis of the qualities of three outstanding teachers of the world. (2) What educators have said constitutes a good teacher. (3) What college students say constitutes a good teacher. This three-fold approach shows a good teacher has a strong personality, a thorough mastery of subject matter, a clear understanding of the learning process, skill in teaching, interest in children, vision, and the human touch. G. B. C.

Building Our Profession. COMMITTEE OF PRINCIPALS FOR THE YEARBOOK OF THE PRINCIPALS AND SUPERVISORS ASSOCIATION OF DAYTON, OHIO. *J. Nat. Educ. Assoc.*, **17**, 207–8 (Oct., 1928).—Attention is given to the benefits made possible by national, state, and local organizations, and to the manner in which they supplement and connect with one another. A. E. C.

The Teaching Load of the Beginner in High School. EARL W. ANDERSON. *Educ. Res. Bull.*, **7**, 280–1, 291–2 (Oct. 3, 1928).—It is evident from the material contained in this report, obtained by an investigation of the Appointments Division, Ohio State University, that "Ohio State University is not preparing its graduates adequately for the work that most of them have to do. There is some question whether any institution can, in four years time, prepare its graduates for the many-sided activities expected of them in teaching. The graduate with a major and a minor in teaching subjects is only partially prepared for the position he will be called upon to fill. Considering the wide diversity of subjects they must teach, with a minimum of supervision, it is a high compliment to the adaptability of the beginning teachers that so few of them fail in their first year of teaching." M. W. G.

Research. RUFUS D. REED. *Neo-Chemto-Ion*, **3**, 21 (Sept., 1928).—A short article with a definite message to the high-school teacher—"If you wish to be more than a mere school keeper, become aware of *your* teaching problems, pursue the research to completion, and then profit by the results." M. W. G.

Local Activities and Opportunities

Through these columns, the JOURNAL desires to render a two-fold service.

1. Local Activities. Keeping its readers in touch with the varied interests of institutions, A. C. S. sections, teachers' asssociations, and other organizations throughout the country. Items of general interest would include: (1) notices of local scholarships or fellowships; (2) notices of any special gifts to chemical organizations or departments—as fellowships, endowments, laboratory gifts, library gifts, etc.; (3) accounts of meetings, social functions, exhibitions, chemical entertainments, etc., which might be suggestive to other organizations (where original or unusual features are included it is desirable that they be described in some detail); (4) news notes concerning persons of sufficient prominence in their respective fields to make their movements of general interest; (5) promotions within, or changes of, personnel of a department; (6) announcements of new or unusual courses in chemical education or special fields of chemistry; (7) notes on new chemistry buildings or laboratories, stressing the unique features.

2. Opportunities. Providing an exchange column for positions. That is: (1) any teacher, who is a subscriber to the JOURNAL, desiring to change his position, may advertise once a year without charge (correspondence will be handled through the editorial office, if desired); (2) any notices of vacancies, in which chemistry teachers and chemists will be interested, will also be published.

The responsibility of reporting items for this section rests entirely with the local institutions and organizations. It would be desirable to have some person connected with each organization and institution appointed to report regularly.

Suitable material sent to the editorial office before the 20th of each month will be published in the following month's JOURNAL. The Editorial Staff must necessarily reserve the right to abridge or totally reject any items submitted. If the above suggestions are followed, however, the necessity for such action will be largely obviated.

Stanford University. The following have been added to the chemistry department staff: Dr. Philip A. Leighton, recently a student at Harvard University of Munich; Dr. Kenneth K. Kelley, formerly National Research Fellow at the University of California; Mr. Herbert G. Tanner, formerly assistant professor at the University of Oregon.

New courses this year include: "Chemical Literature and Libraries," given by the University Librarian, Dr. Nathan Van Patten; "The Laws and Concepts of Modern Chemistry," by Professor Stewart W. Young; and "Photochemistry," by Dr. Leighton.

The honor society, Phi Lambda Upsilon, has donated a perpetual cup to be kept on exhibition in the department and inscribed each year with the name of the most meritorious student in general chemistry. Each such student is also to be given a gold medal, suitably engraved and containing on it the emblem of the society.

Long Island University is now entering upon the second year of its existence in its newly acquired and equipped building at 300 Pearl Street, Brooklyn, with an enrolment of nearly eight hundred. Two new chemical laboratories have been installed which will accommodate 576 students—one for the freshman work and one for the sophomore courses. The enrolment in the chemistry courses is now 425 and the chemistry staff numbers seven. The personnel of the department staff is as follows: Professor, Dwight L. Scoles, Ph.D.; Assistant Professor, Elmer L. Sargent; Instructors, Arthur S. Williams and Ralph H. Hansen; Assistants, Albert Cleghorn, Victor Sabbetta, and Frank S. Griswold. Two other laboratories of the same size as the ones installed this year have been planned and will be equipped as soon as needed.

University of Chicago. Prof. F. C. Koch, chairman of the department of physiological chemistry, spoke on "The Provitamin D Problem," at 8 P.M., Wednesday, November 7th, in the Ida Noyes Theater. This meeting was held under the auspices of Kappa Mu Sigma, graduate women's chemical society.

Eugene U. Still, who received his Ph.D. in physiological chemistry at the Summer

Convocation has been appointed instructor in the department of physiology.

Felix Saunders, Ph.D., 1928, is now an instructor in physiological chemistry.

Professor Frumkin of the Karpov Chemical Research Institute, Moscow, Russia, and a visiting professor at the University of Wisconsin this year, delivered two lectures recently at the University of Chicago.

Professor A. J. Rabinovitch, head of the department of colloid chemistry at the Karpov Chemical Research Institute, Moscow, Russia, was a recent visitor at the Kent Laboratory.

Professor Harkins presented a paper on "Surfaces and Their Importance," on October 26th, at the Seventh Regional Meeting of the A. C. S. held at Lexington, Kentucky.

J. Meiler has been appointed instructor in chemistry at the University of Nebraska.

H. Cohn, Ph.D., 1928, is now connected with the Sprague Institute.

David N. Rickles, Ph.D., 1928, has accepted the position of chemist for the Board of Education of the City of Chicago.

Two appointees of the Nitrogen Fixation Laboratory are now working at the Kent Laboratory under the direction of Professor Kharasch.

Professor J. Stieglitz gave a lecture Friday, October 26th, on "The Nature of Chemical Processes," before the University of Wisconsin Extension Division at Milwaukee.

T. W. Day, Ph.D., 1925, has been appointed assistant professor of physiological chemistry in the Marquette University School of Medicine.

Dr. Anson Hayes, 1921, Ph.D., has resigned his position of assistant professor of chemistry at Iowa State College, to accept the position of Chief of the Research Laboratory of the Armco Company at Middleton, Ohio.

The Journal Club of the Kent Laboratory began the year's program November 1. Mr. Albert Meyer gave a paper on "Free Inorganic Radicals."

University of Pennsylvania. Martin J. Kilpatrick, Ph.D., from the Bronstead Laboratories, University of Copenhagen, has joined the teaching staff in physical chemistry at the University of Pennsylvania.

The Pennsylvania State College. Dr. Walter Eddy, professor of biochemistry, Columbia University, well-known authority on nutrition, addressed the November meeting of the Central Pennsylvania Section of the American Chemical Society on the subject, "Studies in the Chemistry of Vitamins." Dr. Eddy outlined the recent research work done at Columbia University and elsewhere on vitamins and pointed out some of the future lines of work. The meeting was well attended and the lecture was very interesting and instructive.

The third annual Priestley lectures given under the auspices of the School of Chemistry and Physics in coöperation with the other departments of science of the Pennsylvania State College, were given this year, November 19th to 23rd, by Dr. H. B. Williams, of Columbia University. Dr. Williams is director of the department of physiology, College of Physicians and Surgeons, at Columbia. The general topic is "Method in Scientific Investigation." A paragraph from the general announcement will serve to indicate the scope of the lectures:

"It is the aim of these lectures to direct attention to certain aspects of the observational and experimental methods, particularly as applied in physical chemistry, physiology, and the medical sciences. Especial attention will be given to the subject of logical thought, to the mathematical mode of thought, and to the nature and limitations of applied mathematics as a means of discovering or aiding in the discovery of hidden relationships among observed phenomena."

The Priestley Lectures deal each year with the borderline field between physical

chemistry and some other branch of science.

The first year's lectures dealt with the borderline between physical chemistry and bio-colloids. They were given by V. Cofman of the Experimental Station of E. I. du Pont de Nemours and Company. The second year's lectures dealt with the borderline between physical chemistry and metallography. They were given by Dr. S. L. Hoyt of the Research Laboratory of the General Electric Company.

Dr. Wheeler P. Davey of the School of Chemistry and Physics has been invited to give the annual Thurston lecture at the mid-winter meeting of the American Society of Mechanical Engineers in December. The Robert Henry Thurston lectures deal with subjects on the borderline between science and engineering. Dr. Davey's subject will be "The Elastic Properties of Materials as Shown by Crystal Structure Investigations."

Construction has been started on the addition to the first unit of the Pond chemical laboratory which was erected some twelve years ago. It is expected that this new unit will be occupied in September, 1929. Much needed additional space will be provided for the chemical library, organic chemistry, and quantitative analysis.

University of Pittsburgh. Professor Alexander Silverman, head of the department of chemistry of the University of Pittsburgh, delivered an illustrated lecture on glass before the Northern West Virginia Section of the American Chemical Society at the University of West Virginia, Morgantown, Wednesday evening, November 14th.

Columbia University. Harold B. Friedman, Ph.D., Virginia, 1927, and Instructor at Maine during the past year has accepted a research assistantship in chemistry at Columbia for the coming year.

Dr. Graham Cook has been appointed Instructor in University Extension in the place of Dr. Ray Crist who is on leave as Cutting Traveling Fellow. He will give instruction in inorganic and physical chemistry.

Professor Marston Taylor Bogert has accepted the following appointments: Associate Editor of the *Journal of the American Chemical Society* for a period of five years; Member of Division of Chemistry and Chemical Technology of the National Research Council for a period of three years; Collaborator, Bureau of Chemistry and Soils, U. S. Department of Agriculture, for one year; Member, Board of Scientific Directors of the New York Botanical Garden.

On Saturday, October 20th, the department of chemistry tendered a luncheon in honor of Dr. Hans Thatcher Clarke, newly appointed professor of biochemistry at the School of Medicine, and Dr. Goodwin L. Foster, newly appointed associate professor of biochemistry.

Dr. H. A. Iddles has returned from a year's leave of absence on a Cutting Traveling Fellowship. Part of the year was spent with Professor Robert Robinson of the University of Manchester, the other half spent with Heindrick Wieland of Munich.

Professor M. T. Bogert lectured before the Kanawha Valley Section of the American Chemical Society at Charleston, W. Va., on November 13th.

On November 13th, Professor V. K. La Mer addressed the Western New York Section of the A. C. S., at Niagara Falls, on "Recent Advances in the Ionization Theory."

Massachusetts Institute of Technology. The laboratory recently established at the Massachusetts Institute of Technology for research in inorganic chemistry has been named the Henry Paul Talbot Laboratory in honor of the late Professor Talbot. A portrait presented by Mrs. Talbot, who was present at the ceremony, was unveiled when the new laboratory was named. Dr. F. K. Keyes, director of chemistry, presided and Professor H. M. Smith, in charge of the division of inor-

ganic chemistry, made an address describing Dr. Talbot's long and distinguished association with the institute, particularly his services in the teaching of chemistry. Dr. Talbot was professor in the department of chemistry from 1892 to 1927.

Carnegie Institute of Technology. Frank N. Speller, director of the department of metallurgy and research of the National Tube Company, was elected chairman of the Metallurgical Advisory Board to the Carnegie Institute of Technology and the U. S. Bureau of Mines at a meeting of the Board in Pittsburgh Friday night, October 19th. Mr. Speller, whose term is for three years, succeeds T. D. Lynch, metallurgist of the Westinghouse Electric and Manufacturing Company.

The evening meeting of the board terminated its Second Open Meeting, which included all-day technical sessions for all who were interested in metallurgical research. More than 150 of the prominent metallurgists of the country attended the sessions to hear reports and discussions of coöperative research in metallurgy that has been conducted during the past four years under the joint auspices of the Carnegie Institute of Technology, the Bureau of Mines, and the Metallurgical Advisory Board.

Special interest was shown in the progress report of the five-year program on studies in the physical chemistry of steel making now being conducted under the three-party agreement and in the reports of the work accomplished by the Bureau of Metallurgical Research of the Carnegie Institute of Technology.

Announcement was made at the session that the following published reports are now available for distribution:

Bulletin **36.** Deoxidation with Silicon and the Formation of Ferrous-Silicate Inclusions in Steel, by C. H. Herty, Jr., physical chemist, U. S. Bureau of Mines, and G. R. Fitterer, research fellow, Carnegie Institute of Technology, and junior metallurgist, U. S. Bureau of Mines—1928, 94 pages and 27 illustrations, price $1.

Bulletin **37.** A Study of the Dickenson Method for the Determination of Non-Metallic Inclusions in Steel, by C. H. Herty, Jr., physical chemist, and G. R. Fitterer, junior metallurgist, U. S. Bureau of Mines, and J. F. Eckel, research fellow, Carnegie Institute of Technology—1928, 27 pages and 4 illustrations, price 50 cents.

Bulletin **39.** Second Progress Report of the Metallurgical Advisory Board to Carnegie Institute of Technology and the U. S. Bureau of Mines, by T. D. Lynch, chairman, Edward Steidle, secretary, 1926–1928, and J. D. Beatty, secretary, 1928. 21 pages. No charge.

Bulletin **40.** Second Progress Report of the Mining Advisory Board to Carnegie Institute of Technology and U. S. Bureau of Mines, by W. L. Affelder, chairman, Edward Steidle, secretary, 1926–1928, and John D. Beatty, secretary, 1928. No charge.

Lexington Section, A. C. S. The 129th regular meeting of the Lexington Section of the American Chemical Society was held in Kastle Hall, University of Kentucky, 4.00 P.M., Tuesday, November 13, 1928. Dr. J. S. McHargue, of the Kentucky Agricultural Experiment Station, spoke on "The Rôle of the Less Common Elements in Plant and Animal Metabolism."

Perkin Medal Award for 1929. By a vote of a committee representing the Society of Chemical Industry the American Chemical Society, the Societé de Chimie Industrielle and the American Electrochemical Society, the Perkin Medal for 1929 will be awarded to Dr. E. C. Sullivan. The award is for his work on various special types of glasses including pyrex. Presentation will be made on January 4th at a joint meeting of the chemical societies to be held at the Chemists' Club, New York.

Fourth Pan-Pacific Science Congress. The Fourth Pan-Pacific Science Congress is to be held in Batavia, Java, May 16 to 25, 1929, under the auspices of the Netherlands Indies Pacific Research Committee and supported by the patronage of the Netherlands Indies Government, according to information received from the Netherlands Government by the U. S. Bureau of Education. Emphasis will be laid on agriculture, although all branches of the physical and biological sciences bearing on tropical life and conditions will be discussed.

The Rumford Fund. For nearly one hundred years the American Academy of Arts and Sciences has maintained a standing committee of seven persons, called the Rumford Committee. This committee receives and deals with applications for grants of money in aid of researches in light and heat, branches of science in which the founder, Benjamin, Count Rumford, was particularly interested. Since 1839, the American Academy, through its Rumford Committee, has made 270 grants of this character, in sums between $25 and $750, averaging about $260.

Applications may be accepted from any duly qualified resident of North America or of the American islands. Applications should indicate the nature of the research and the particular aid sought. Grants may be applied to furnishing apparatus which remains the property of the Academy, or to the printing and publishing of the results; but are not applicable to assistants. The research subjects within the scope of the fund are light and heat, including x-rays. Applications should be addressed to the Rumford Committee, American Academy of Arts and Sciences, Boston.

Eastman Kodak Company, Harrow, England. The establishment of a research laboratory in photography and associated sciences as part of the English plant of the Eastman Kodak Company at Harrow, near London, was announced November 10th. Dr. Walter Clark, formerly of the staff of the British Photographic Research Association and the National Science Library, has been appointed director.

The research laboratory at Harrow will be patterned on the Eastman Kodak Research Laboratories at Rochester, which under the direction of Dr. C. E. K. Mees, have grown in 16 years to have a staff exceeding 150 in number. These laboratories have produced numerous important photographic inventions and improvements, the most recent of which is color motion pictures for amateur photographers.

Dr. Clark will return to England on November 14th on the Aquitania, after having spent several months studying the organization and methods of the Laboratories in Rochester.

The new laboratory in England, while coöperating closely with the corresponding organization in America, will not merely supplement the Rochester work but will pursue its own individual lines of research. The expectation is that two laboratories, working independently in different countries on various problems, but comparing and sharing their results, will facilitate even greater photographic progress than has attended the work of the Eastman Kodak Research Laboratories since Dr. Mees came to Rochester in 1912.

In the past year the Harrow Plant has been added to by a film storage building, a silver nitrating building, and a camera factory which is now manufacturing on a full schedule. It is the largest of the Eastman Kodak Plants abroad. The other foreign Eastman Kodak factories are at Vincennes, France; Copenick, Germany; Vacz, Hungary; and Melbourne, Australia.

The Illinois Association of Chemistry Teachers. A joint meeting of the Association and the Physical Science Section of the High-School Conference was held at Urbana, on November 23, 1928. The program of interest to chemistry teachers was as follows:

MORNING SESSION, 9 A.M.

Physics and Chemistry: Herman Ridlen, Chicago Heights, Illinois, presiding.

"The Acoustics of the Outdoor Theater," Prof. F. R. Watson, University of Illinois.

"X-Rays in Everyday Life," Prof. G. L. Clark, University of Illinois.

AFTERNOON SESSION, 2 P.M.

Chemistry Group: Miss S. Aleta McEvoy, Rockford, Illinois, presiding.

"Place of Science Clubs in the High-School Curriculum," Louis A. Astell, West Chicago High School.

"Unit System as Applied to Teaching High-School Chemistry," Russell S. Howard, Lyons Township High School.

"Demonstrations of Practical Experiments in Chemistry," Harold H. Metcalf, Oak Park Township High School.

"General Discussion of the Aims of the Illinois Association of Chemistry Teachers for 1928–29," Dr. Rosalie M. Parr, University of Illinois.

The officers elected were these:

President, Mr. Dorr Simer, High School, Decatur, Illinois; *Vice-President,* Miss S. Aleta McEvoy, High School, Rockford, Illinois; *Secretary-Treasurer,* Rosalie M. Parr, Univ. of Illinois, Urbana, Ill.; *Senator,* representing high schools—Mr. H. W. Garnett, 205½ North St., Normal, Illinois.

The Illinois Association is offering a prize to the high-school student who presents the best exhibit at the spring meeting. A committee, of which Mr. John B. Phillips, of Pekin, is chairman, was appointed to arrange for this exhibit and to determine the form of an attractive prize.

The work of a committee on "Methods" was arranged with twenty-five teachers coöperating. It is planned that a report of this work will be made at the spring meeting, on May 3rd, by the chairman, Miss Mabel Spencer, of Granite City.

Iowa State College. The following statement was mimeographed and handed to each of the freshmen (about 1100) enrolled in chemistry. Three hundred nineteen expressed an intention to enter essays in the contest.

The American Chemical Society Prize Essay Contest for 1928–1929

Mr. and Mrs. Francis P. Garvan are offering eighteen prizes totaling $6000 for the best essays submitted to the committee on prize essays of the American Chemical Society. Copies of the announcement, including some references and the rules of the contest, are posted on the bulletin boards of the chemistry building.

1. In order to encourage the freshmen students of Iowa State College to enter the contest, credits in both English and chemistry will be given for creditable essays whether they do or do not win prizes.

A. English

1. Credit for a term theme in English will be given during the winter quarter if arrangements are made with the English teacher early in the winter quarter.
   1. If a student submits his contest essay to his teacher in English he shall submit but once for corrections.
   2. The English teacher shall limit his assistance to the use of the number symbols of the Century Handbook, and shall leave the student to find for himself some better form of expression.

B. Chemistry.

1. The presentation of a creditable essay to the committee on prize essays of the American Chemical Society shall earn an addition of from 2 to 5% to the term grade to any student enrolled in a freshman course in chemistry during the winter quarter, 1929.

2. A carbon copy of the essay submitted to the committee on prize essays shall be presented to the instructor in chemistry who will determine the addition which is to be made to the term grade.

3. In so far as possible the decision to

enter the contest shall be signified before November 10, 1928, but no student shall be barred from the contest because of failure to enter before the winter quarter begins.

4. Chemistry instructors may answer questions of informational nature, furnish references, and assist in the use of journals, indexes, and library materials.

5. Instructors in chemistry should not assist a contestant in the choice of information to be presented, the arrangement of the material chosen, or the forms of expression to be used.

University of Arizona and Arizona Section, A. C. S. Dr. Homer LeRoy Shantz, internationally known ecologist and plant physiologist, who was elected President of the University of Arizona last fall, assumed presidency July 1st. On September 27th, Dr. Shantz addressed the Arizona Sigma Xi Chapter on: "The Relation of Plant Growth and Transpiration to Weather Conditions."

On November 9th, Dr. A. E. Douglass, professor of astronomy and astronomer at the Steward Observatory of the University of Arizona, addressed the Arizona Chapter of Sigma Xi on the subject: "The Cyclograph and Its Use in the Analysis of Tree Ring Measurements."

The Arizona Section of the American Chemical Society, in response to an invitation from the Pacific Coast Intersectional Division, voted to join with that group of western chemists. This arrangement will make it possible for Arizona chemists to participate in the programs and make contacts with fellow-chemists when it is not possible to attend the general meetings of the Society in the East.

On October 25th, Dr. E. P. Mathewson, professor of mine administration of the University addressed the Section on the topic: "A Trip to Rio Tinto, the Oldest Mine in the World." The lecture was illustrated with lantern slides and proved very interesting.

On November 15th, Dr. E. H. Warner, professor of physics, addressed the Section, choosing the topic: "The Determination of Avogadro's Number." The various classical methods were derived mathematically and the values by these methods compared. An ultramicroscope was set up to demonstrate the Brownian movement.

Dr. Ernest Anderson addressed the Physical Sciences Section of the Central Arizona Teacher's Association at Phoenix, November 10th, at a round-table discussion on "The Teaching of High-School Chemistry." He also addressed the Southern Arizona Section meeting of High-School Chemistry Teachers in session at Tucson, November 2nd, on "The Chemistry of Colloids," illustrating his talk with experiments.

Word has been received from Mr. W. E. Roseveare, a former fellow in chemistry, who has been pursuing his studies toward the Ph. D. degree at the University of California, that he has fulfilled the requirements, and has been appointed an instructor in chemistry at the University of California for next year. He held scholarship records both at Arizona and California.

A paper entitled "Cupric Oxide as a Standard in Iodimetry and a Comparison of It with Other Iodometric Standards," by T. F. Buehrer and C. Morgan Mason, has been accepted for publication in *Industrial and Engineering Chemistry*.

Arrangements have been made by the Arizona Section and by the local Chapter of Sigma Xi to secure Dr. F. C. Whitmore to give two lectures at the University during his tour of the West next March.

The high schools of Arizona have displayed considerable interest in the annual Chemistry Prize Essay Contest ever since its inception. To date, four national first prizes have been won by Arizona high-school pupils: Donald Vivian of Phoenix Union; Paul Whiteley of Bisbee, now studying at Stanford under a Prize Essay Scholarship; May Dunn of Tucson; and Esther Laine of Bisbee, who is studying at the University of Arizona this year.

Dr. T. F. Buehrer, Contributing Editor

for the JOURNAL OF CHEMICAL EDUCATION from Arizona, addressed the Science Section of the Southern Arizona Teachers' Association at Tucson, November 2nd, on the attractive features of the JOURNAL, urging that the JOURNAL be placed in every high-school library and made available for perusal to every pupil. Teachers were encouraged to submit manuscripts for publication in cases where novel and successful methods or devices have been developed to make the teaching of chemistry more effective.

Dr. Charles H. Herty Will Concentrate His Energies upon the Chemical Development of the South

In the course of a letter to the *Manufacturers Record*, Dr. Charles H. Herty, former president of the American Chemical Society, and now advisor of the Chemical Foundation, writes as follows:

"For the past several weeks I have been weighing carefully the question as to whether I should continue in work chiefly national in its character, with only incidental bearing on the South, or whether I should modify this program and place the main emphasis on doing whatever is in my power to aid in the industrial building up of the South, especially the industries directly affected by chemistry.

"I have decided on the latter course, and beginning November 1, I am going to cast my lot with the folks down home. I am going to open a New York office at 101 Park Avenue, and during the next four or five years I shall give the bulk of my energy to this work, dividing my actual time about equally between New York City and my connections in the South.

"Already the trend of the chemical industries is strongly toward the South. The crest of the wave is right now in Virginia and West Virginia. One needs only to travel from Hopewell, Va., westward and through the Kanawha Valley in West Virginia to see this wonderful and very recent development. Nitrogen fixation; rayon; paper; caustic soda; chlorine; refractories; glass; products from natural gas; barium compounds; synthetic organic chemical compounds—and the most of these products are being manufactured from cheap raw materials, by the finest type of labor, in an equable climate. The advance wave of this movement is already being felt, though not so strongly, in the states farther south.

"This country is just beginning to awaken to the great natural resources of the South. There are many in the North who are seeking investments, if they can only know that these investments are sound; there are many localities in various parts of the South which possess combinations of raw material and of power which can profit enormously by a wise and experienced development of these natural assets, which until recently have yielded up only a little of their real potentialities.

"I have a longing to try to be of help in bringing these two elements together.

"I shall retain a part-time connection with the Chemical Foundation in order to aid the great work it is doing of an educational character, and especially to aid in arousing public sentiment which will lead to better provision for more intensive research on the fundamental problems of health, especially as they relate to chemistry."

As one of the foremost chemists of America, long identified with many great movements for the development of the chemical industry in this country, this announcement of Dr. Herty is of particular value to the South and, indeed, to the country at large, for the development of the chemical industry in the South is one of the most marked features of the progress of that section.

Plasticity Symposium, Lafayette College. The third Plasticity Symposium is to be held December 17 and 18, 1928, at the Gayley Chemical and Metallurgical Laboratories at Lafayette College, Easton, Penna., under the joint auspices of The Lehigh Valley Section of the A. C. S. and the Research Committee of Lafayette College.

Dr. Markus Reiner, of the Department of Public Works, Jerusalem, is to be the guest speaker. He has brought to this country a viscometer of the Cuette type which he had constructed at the Wimbledon Technical Institute after the designs of Professor Emil Hatschek. With it he is testing out some of the theories of plasticity obtained with the capillary tube type of plastometer.

The program is as follows:

First Session

Monday Afternoon—2 o'clock

1. "Welcome," William Mather Lewis, President of Lafayette College.
2. "Some Fundamental Definitions and Some of Their Consequences," Eugene C. Bingham, Lafayette College.
3. "Some Characteristics of the Flow of Nitrocellulose Solutions," D. R. Wiggam, Hercules Powder Co., Kenvil, New Jersey.
4. "The Plasticity of Single Crystals," Wheeler P. Davey, Pennsylvania State College.

Second Session

Monday Evening—8 o'clock

5. "The Theory of Plastic Flow in the Rotation Viscometer," Markus Reiner, Department of Public Works, Jerusalem, Palestine.
6. "Plasticity of Solvated Colloids," S. E. Sheppard and R. C. Houck, Eastman Kodak Co.

Third Session

Tuesday Morning—9 o'clock

7. "The Structure of Lyophilic Dispersions," Elmer O. Kraemer, E. I. du Pont de Nemours & Co., Wilmington, Del.
8. "The Value of Routine Tests in Measuring Consistency," S. Bradford Stone, College of the City of New York.
9. "A Modified Plastometer for Industrial Use," D. V. Gregory, E. I. du Pont de Nemours & Co., Philadelphia, Pa.
10. "The Measurement of Consistency of Paints," George S. Haslam and L. B. Grady, Jr., New Jersey Zinc Co., Palmerton, Pa.

University of Cincinnati. The University of Cincinnati is conducting a series of talks on "Taking the Mist Out of Chemistry" over WLW, the 50 kw. station of The Crosley Radio Corporation at Cincinnati.

The talks are given at 7:15 to 7:30, Cincinnati time, every Wednesday evening, by Dr. Saul B. Arenson, Assistant Professor of Chemical Engineering.

The titles of the talks which have already been given are:

(1) "The Romance of Chemistry;" (2) "How Big Are Atoms;" (3) "The Air We Breathe;" (4) "Decomposed Water;" (5) "What We Drink;" (6) "That Poisonous Green Gas;" (7) "Common Table Salt;" (8) "Sulfur and Molasses;" (9) "Your 50 Pounds of Sulfuric Acid."

The schedule of future talks is as follows:

(10) Dec. 19, "Making Nitrogen Work."
(11) Dec. 26, "Black Diamonds."
(12) Jan. 2, "Carbon Monoxide and Other Fuels."
(13) Jan. 9, "The Story of Coal Tar."
(14) Jan. 16, "Dyes That Plants Never Thought of Making."
(15) Jan. 23, "Industrial Alcohols."

Georgetown University. The seventh annual meeting of the American Association of Jesuit Scientists (Eastern States Division) was held at Woodstock College, Woodstock, Md. on Aug. 25–27, 1928. In the absence of the Rev. Edward C. Phillips, president of the association, the chair was occupied by the Rev. Richard B. Schmitt. The Rev. Vincent A. McCormick, S.J., Rector of Woodstock College, delivered the address of welcome which was followed by the presidential address delivered by the Rev. Richard B. Schmitt, S.J., entitled "The Evolution of the Elements and the Stability of Complex Atoms." On the afternoons of Aug. 25th and 26th the various sections held their separate meetings.

At the *Chemistry Section* papers were read according to the following program: "Quantitative Analysis of Steel," Rev. Richard B. Schmitt, S.J.; "Philosophy of Chemical Theories," Rev. T. P. Butler, S.J.; "Preparation of Glyceryl Ester of Lauric Acid," Rev. H. McCullough, S.J.; "Literature Searches in Chemistry," Francis W. Powers, S.J.; "Quantitative Data on Acid Analysis," Rev. G. L. Coyle, S.J.; "The Present Status of Valence," Rev. J. J. Sullivan, S.J.; "Mathematical Preparation for the Study of Chemistry," Rev. M. J. Ahern, S.J.; "Sir Isaac Newton, Chemist," Rev. Lawrence C. Gorman, S.J.; "Creative Chemistry," Rev. G. F. Strohaver, S.J.; "University Research," Rev. J. J. Sullivan, S.J.; "Hydrogen-Ion Determination," Rev. T. J. Brown, S.J.

On Monday morning, Aug. 27th, the final general session was held. At this meeting the Rev. Edward C. Phillips was reëlected president, Rev. Lawrence C. Gorman, S. J., was elected secretary and the Rev. John L. Gipprich, S.J., Editor of the *Bulletin*.

The reports of the secretaries of the different sections showed that the following officers had been elected for the coming year:

Biology: *Chairman*, Rev. John A. Frisch, S.J.; *Secretary*, Mr. Charles Berger, S.J. **Chemistry:** *Chairman*, Rev. Richard B. Schmitt, S.J.; *Secretary*, Rev. Lawrence C. Gorman, S.J. **Mathematics:** *Chairman*, Rev. Edward C. Phillips, S.J.; *Secretary*, Mr. Thomas D. Barry, S.J. **Physics:** *Chairman*, Rev. William G. Logue, S.J.; *Secretary*, Mr. Joseph R. Hearn, S.J.

The chemistry department of Georgetown has the following new men on its staff: John Connolly, M.S., Thomas McGinn, B.S., both of Holy Cross College, Worcester, Mass.; Alfred Huntsinger, A.B. of Canisius College, Buffalo, N. Y., and John Simpson, A.B., of Georgetown University.

Graduate work in the field of chemistry has been developing very well. The following have undertaken studies for their Ph.D. degrees: Arthur A. Espenscheid, Francis P. Wilson, John Q. Connolly. Thomas McGinn, Alfred Huntsinger, John Simpson, and James Cavanough have begun studies for M.S. degrees.

On Monday evening, Nov. 5th, the Chemistry Academy displayed for its members a motion picture entitled "Oxygen, the Wonder Worker."

Thursday evening, Nov. 22nd, at the first public meeting of the current scholastic year of the Chemistry Academy, a capacity assembly was present to hear Major General Amos A. Fries, Chief of the Chemical Warfare Service of the United States Army, deliver a learned and exceedingly interesting address entitled "Chemistry in Wartime and Peace." General Fries has been the acting head of this recently established branch of the service ever since its inauguration during the late World War. His speech was highly interesting and exceptionally well received by his appreciative audience.

In Memory of Edgar Fahs Smith. A meeting in memory of Edgar Fahs Smith, formerly provost and Blanchard professor of chemistry in the University of Pennsylvania, was held on December 4th at 4 o'clock in the Irvine Auditorium of the university. Addresses were made by Dr. Francis X. Dercum (class of '87 medical), president of the American Philosophical Society; Dr. Marston T. Bogert, professor of organic chemistry at Columbia University, and Dr. Josiah H. Penniman, provost of the university.

University of Nebraska. Doctor George L. Clark of the University of Illinois addressed the Nebraska Section of the American Chemical Society, on November 21st, upon the subject "What Can the Chemist Do with X-Rays?" The meeting was held in the chemistry lecture room of the University of Nebraska. Chancellor-Emeritus, Samuel Avery, was formally installed as the new president of

the section at the close of the meeting.

The first annual scholarship award for the highest scholarship in freshman chemistry was presented to Homer Deadman of Falls City, Nebraska, at a public meeting of the Rho chapter of Phi Lambda Upsilon the evening of November 22nd. Aside from the personal medal the winner has his name carved upon the Phi Lambda Upsilon Freshman Scholarship Cup. Doctor Fred Upson, chairman of the department of chemistry, gave the address of the evening upon "How Discoveries in Science Are Made." All freshman chemistry students were especially invited to the meeting.

Colorado State Teachers' College. A series of radio talks on popular science were given over radio station KFKA of the Colorado State Teachers' College on December 3, 4, 5, 6, and 7, 1928.

These lectures were sponsored by the chemistry department of Greeley, Colorado, High School and were so arranged as to be of interest to both city dwellers and farmers. They treated the subject of chemistry in a non-technical manner. It is hoped that this series of talks will stimulate in both rural and urban districts, a greater interest in every-day chemistry and the part it plays in every activity of mankind.

Teachers' College, Columbia University. Two new trustees of Teachers' College, named November 22nd, are: M. Gordon Neale of the University of Missouri (alumni representative); and Owen D. Young of the General Electric Company and of the Radio Corporation of America.

Ninth Annual Ohio State Educational Conference. April 4th, 5th, and 6th are the dates of the Ninth Annual Ohio State Educational Conference at Columbus. "Evaluating education" will be the keynote of this three-day meeting conducted by the College of Education at the Ohio State University. Each year the attendance materially increases. Last year's gain of 335 pushed the number who took part in the three general and 38 sectional meetings to more than 4800. Since 1923 the attendance has practically doubled.

To extend the "conference" idea, allowing group interests to have even wider consideration, Friday and Saturday forenoons and Friday afternoon will be given over to sectional group meetings. General sessions will be held Thursday and Friday nights only. The customary Saturday morning general session will give way to sectional meetings.

Groups admitted to the Conference for the first time will be represented this year by sections concerned with adult education, higher education and attendance supervisors, school nurses, and visiting teachers. In addition to the three new groups mentioned, one or more sectional meetings will be given to problems of groups interested in biological science, city superintendents, clinical psychology, commercial education, county superintendents, educational and intelligence tests, elementary principals, elementary teachers, English, geography, high-school principals, history, home economics, industrial and vocational education, journalism, junior high-school principals, kindergarten and primary teachers, Latin, mathematics, modern language, music, non-biological science, parent-teacher association, physical education, religious education, school business officials, school librarians, special education, teacher training, and village and consolidated school superintendents.

Austrians Make Gas from Lignite. Gas for fuel and illuminating purposes can be made satisfactorily from lignite, recent experiments at Marburg on the Drau in Styria indicate. This work is being watched with much interest by Austrian engineers and industrialists, because up to the present Austria has had to import high-grade anthracite for its gas-works.—*Science Service*

Recent Books

An Introduction to the Chemistry of Plant Products. PAUL HAAS, D.Sc., Ph.D., Reader in Plant Chemistry in the University of London, University College; and T. G. Hill, D.Sc., A.R.C.S., Reader in Vegetable Physiology in the University of London, University College. Fourth edition. Volume I: On the Nature and Significance of the Commoner Organic Compounds of Plants. Longmans, Green and Company, 55 Fifth Avenue, New York, 1928. xvi + 530 pp., one text figure. 14 × 22 cm. $6.50 net. Printed in England.

The book is described as "a work primarily intended for students of botany reading for an honours degree and for those who require information on plant chemistry. The subject matter deals with the occurrence, chemistry and biological significance of the chief products of the plant's activity; viz., fats, carbohydrates, glucosides, tannins, pigments, proteins and enzymes. The great increase in biochemical investigations during recent years has necessitated a thorough revision of the book which, for the most part, has been re-written."

The present volume is an improvement and modernization, as it were, of an already well and favorably known text. The authors have very carefully adhered to their purpose as quoted above. The honors graduate in botany, after an undoubtedly profitable reading of the book, can expect to use it to look up the chemistry of substances mentioned in his botanical reading. The text and format are designed for easy reading and the index and table of contents are prepared for convenience in reference. To reduce the mention of strictly animal physiology the section on co-enzymes in the last edition has been removed because it drew mostly upon work with animals. The treatment of this subject is in the section on activators. The vitamins are not mentioned, probably for the same reason. Sections on lignified membranes, nucleic acids, and the colloidal nature of protoplasm have been added. Directions for the preparation of solutions to be used in experiments are now given, and in nearly all of the sections a more logical and easier presentation has been striven for through rewriting and rearrangement. New work, including some papers of 1928, has been mentioned, resulting in a general expansion amounting to over a hundred pages.

For the student whose major subject is chemistry and whose minor is botany, as distinguished from the botanist, the use of this book as a foundation textbook in the United States might not be so felicitous. He should know it as a reference book, but it is rather specialized as a British text for botany students. Many of the references are likely not to be available in the smaller libraries in the United States and the collateral reading assignments are in the main in other British volumes. The correlation with American analytical practice, textbooks and literature would devolve upon the instructor. The American student of chemistry interested in botany should be given, for example, frequent and pointed reference to the Methods of Analysis of the American Association of Official Agricultural Chemists.

E. L. GREEN
WASHINGTON AGRICULTURAL EXPERIMENT STATION

Essentials of Qualitative Chemical Analysis. JOHN C. WARE, Sc.M., Ph.D. First edition. John Wiley and Sons, Inc., New York City, 1928. 11 figures, 30 tables, 17 illustrations, 6 color plates.

xii + 351 pp. 15 × 23 cm. $3.50 net.

"Essentials" means necessities. That is what this book contains—everything that is necessary to make a well-rounded course of qualitative analysis with the idea that this is an essential part of the foundation necessary for the chemist in whatever line of work he may undertake. Thus the author justifies the inclusion of applications of theoretical principles by stating in his preface, which he says is written primarily for the student, "You never lose sight of the fact that qualitative analysis is not necessarily an end in itself but a most efficient means of developing chemical reasoning power which may prove invaluable in later research work. Your final goal is surely not to be a weigher of samples in a large routine laboratory."

The book is divided into five parts. Part I consisting of 84 pages shows the application of principles of homogeneous and heterogeneous equilibrium to reactions which are used in qualitative analysis. The usual principles are developed in a clear and easily assimilable manner and are followed by exercises along these lines for the student.

Part II, consisting of 140 pages, gives preliminary experiments to be performed on solutions of the individual metal ions and directions for analyzing mixtures or unknowns containing one or more of these ions. The order of studying the groups begins with the silver group. Following the experiments on the cations of each group is a discussion which summarizes the properties which have been observed and shows why those to be used in the analysis were chosen. The directions are followed by notes explaining details of the procedures by alternative tests which may be used and by a tabular outline of the separation. The cations are separated into the usual groups by the ordinary group reagents. Group IIB is separated from Group IIA by means of sodium polysulfide, but by carrying out the operation at room temperature mercuric sulfide is said to be left in Group IIA. This is contrary to such authorities as Treadwell-Hall and Fresenius and to the experience of the reviewer.

Part III, in 61 pages, deals with the anions in much the same fashion that Part II does with the cations. The identification of the anions consists of individual tests after being approximately identified by using silver nitrate, a mixture of barium chloride and calcium chloride or dilute hydrochloric acid followed by hot 12N sulfuric acid on separate portions.

Part IV consisting of 32 pages correlates the analysis for both cations and anions and introduces the subject of the complications caused in cation analysis by the presence of anions such as phosphate, oxalate, acetate, etc., and gives directions for analysis in their presence. This part also includes directions for dissolving nonmetallic solids, metals, and non-ferrous alloys. Special directions for gold and platinum alloys and for silicate analysis are given.

Part V contains outlines for one or two semesters of laboratory work, solubility tables, directions for preparing reagents, list of apparatus required, and atomic weight table.

The innovation which this book introduces is the six color plates, giving the student some idea of colors which precipitates, fusions, beads, flame tests, etc., should have. The reproduction of the colors, particularly those of the flame tests, is none too good. The colors representing the precipitates are better, but being solid colors cannot replace entirely the memory of a precipitate with both its form and color.

The seventeen illustrations are halftone reproductions of photographs of various control and research laboratories. By seeing them the student will realize the great diversity of manufacturing plants which require analytical work and thereby be stimulated to learn more about the subject.

As a whole the book is well written with few typographical errors and should find a place among the many texts already used

in this field but the above-mentioned discrepancy in separating Groups IIA and IIB should cause this procedure to be accepted with caution.

CARL OTTO
UNIVERSITY OF MAINE

Elementary Laboratory Experiments in Organic Chemistry. ROGER ADAMS, Professor of Chemistry, University of Illinois. JOHN R. JOHNSON, Assistant Professor of Chemistry, Cornell University. First edition. The Macmillan Company, New York, 1928. xi + 305 pp., 19 figures. 14 × 21.5 cm. $1.90.

This laboratory manual is designed for the use of students who are beginning the study of organic chemistry, and is compiled with the idea of placing before the student the more important laboratory procedures and technic of organic chemistry.

The book is divided into two major parts. The first is devoted to a clear exposition of the various physical operations utilized for the purification of organic compounds. Such operations as distillation, recrystallization, filtration, etc., are described and the student, by experiment, becomes thoroughly acquainted with the unit operations of the laboratory before applying the same to the preparation of simple organic compounds.

The second part is devoted to the preparation of typical organic compounds. Here the student applies the unit operations of Part I to the synthesis of pure organic compounds. Detailed directions and pertinent questions accompany each preparation and, in a few instances, qualitative tests are introduced to illustrate simple tests or reactions.

Any laboratory manual in organic chemistry should accomplish two objects. First, it must train a man in the technic of the science, and second, it must illustrate clearly the application of reactions learned in the classroom to practical problems of synthesis. This manual satisfies the above requirements to a marked degree. While the use of qualitative tests would permit the covering of more material, it also would fail to develop technic which is a serious drawback. Such tests at best leave but fleeting impressions on the mind of a beginner and are soon forgotten. A proper technic developed by the use of preparations, however, remains an asset always and permits the student to advance as rapidly in the laboratory as his theoretical background may permit.

The preparations are well chosen and cover very well the simpler typical organic reactions and compounds, with one exception: the proteins. Due to difficulty in preparation, qualitative tests might be used to advantage in this case.

This manual is indeed a very valuable contribution to the teaching of elementary organic chemistry in the laboratory and will, no doubt, be most welcome to many engaged in this work.

JOHN J. DONLEAVY
YALE UNIVERSITY

Laboratory Manual of Elementary Physical Chemistry. EDWARD MACK, JR., AND WESLEY G. FRANCE, Ohio State University. D. Van Nostrand Company, New York, 1928. xi + 195 pp., with 40 figures. 14.5 × 22 cm. Cloth, $2.00.

Experience has shown that these experiments "are quite workable, that they arouse and sustain the interest of the students, and that the present selection of topics distributes the emphasis somewhat more appropriately over the entire field of physical chemistry than has heretofore been done in some of the manuals." Less time than usual is devoted to molecular weight determinations, and in addition to the type of experiments usually included in physical chemistry, the book contains experiments dealing with thermionic tubes, thermal conductivity of gases, size of molecules, rate of settling of fine precipitates, and light absorption by solutions. There are thirty-five experiments, about two-thirds of which are expected to be done by

the student in a year, so that there is considerable latitude in selection of experiments.

There are also three exercises dealing with units and dimensions, slide rule, and errors in measurements.

In addition to experimental directions, each experiment has a brief discussion of the theory involved and questions or directions for the treatment of the experimental results, together with additional textbook references. The introduction contains a list of books which should be available to the student in the laboratory. While this manual may be used with any text it is issued "as a companual volume to Dr. Taylor's own text of Elementary Physical Chemistry."

The book is well written, the choice of experiments quite large, and should prove of interest and value to the teachers of physical chemistry.

D. C. LICHTENWALNER
DREXEL INSTITUTE

The Protamines and Histones. ALBRECHT KOSSEL, Prof. Physiology in University of Heidelberg. Trans. from original German manuscript by W. V. Thorpe, M.A., Ph.D., Lecturer in Biochemistry in University of Birmingham. Monograph on Biochemistry. Longmans, Green & Co., New York and London, 1928. xi + 107 pp. 15.5 × 24 cm. $3.25.

The manuscript of this monograph was completed only a few days before the author's death. As he states in a rough draft of the preface which was found, his investigations on protamines and histones were undertaken chiefly from biological aspects; he was first led to study the evolutionary changes which protein undergoes in the differentiation of tissues, and he found these changes to consist in the production of proteins which are distinguished by basic properties; these proteins are biologically the more important because they are formed in the chief organ of the cell, the nucleus, where they are concerned with cell division, fertilization and inheritance.

Although our knowledge of the histones and protamines has thus far attained no significance in "experimental" biochemistry and has been derived only from the descriptive side, the pioneer explorations made by Kossel and his students are a monumental achievement. Many of their investigations besides being contributions to the subject of his special interest enriched our conceptions of the fundamental structure of protein.

The monograph is a detailed summary of the methods of separation and quantitative estimation of the bases and monamino acids, of the preparation of protamines, their properties and constitution. Part II deals similarly with the histones, with particular reference to that of the thymus; the concluding pages are devoted to the chemical relation of the protamines and histones to other basic proteins and their biological significance. The bibliography contains 204 entries.

Rarely is it given to a man to work almost uninterruptedly at his chosen task for a full half century; and when at the age of seventy-five, before laying down his pen, he has the opportunity to summarize the advances made, this is a gift of the gods, their tribute to a great personality. He has left an enduring legacy to biochemical science; all those who in days to come endeavor to solve the mystery of protein chemistry will enter into his labors.

H. A. MATTILL
STATE UNIVERSITY OF IOWA

Industrial Chemistry. An elementary treatise for the student and general reader. EMIL RAYMOND RIEGEL, Ph.D., Professor of Physical and Industrial Chemistry, University of Buffalo. The Chemical Catalog Company, Inc., New York City. 649 pp. 15 × 23 cm. $9.00.

It is, perhaps, impossible to write an "Industrial Chemistry" that will please the majority of readers. It certainly is impossible for one man to write a satisfactory text. Professor Riegel has done extremely well, and though his book is

attractive and interesting, it still must be considered an out-of-date text.

To substantiate this statement, it is only necessary to glance over the book and see the many omissions of important recent developments. For example, the vanadium pentoxide method for the manufacture of sulfuric acid; the use of quartz and glass in hydrochloric acid manufacture; refrigeration based upon absorption; modern continuous methods of fractionation, especially in the methyl and ethyl alcohol industries; synthetic lactic acid; alcohol motor fuels with anti-knock properties; phenol manufacture from chlorbenzene; deoxidants for rubber; and the partial oxidation of natural gas.

There are, of course, several misstatements of fact due to the lack of knowledge of the particular subject by the author. These, however, should be expected. It is very difficult to see how that could be avoided entirely.

The selection of material is not necessarily what many readers would expect; for example, considerable space is given to the Dubbs cracking process while the Holmes-Manley, a modern and efficient process, is barely mentioned. The chapter on lacquers occupies less than a page and gives a rather poor picture of this new and enormous industry. In the chapters on appliances, no mention is made whatsoever of stills, columns, or scrubbing towers.

On the other hand, there are several chapters that should be specially commented. One is on patents and the other on artificial silk. Several of the chapters on appliances are exceedingly good as is also the chapter on the materials of construction.

In spite of the adverse criticism of this book, the reviewer wishes to point out that he has never read a more nearly up-to-date and more entertaining book on this subject. The book can be most heartily recommended to students, but its sale will be handicapped by its high price.

D. B. KEYES
UNIVERSITY OF ILLINOIS

Traditional Examinations and New-Type Tests. C. W. ODELL, Ph.D., Assistant Director, Bureau of Educational Research, University of Illinois. The Century Company, New York and London, 1928. xiii + 469 pp. 13 × 20 cm. $2.50.

Several texts on the general subject of examinations and tests have recently come from the press. The present text covers the usual range of topics including historical background of the testing movement, discussion of advantages and disadvantages of the new-type tests in comparison with the traditional examinations, instructions on how to use new-type examinations, how to interpret the scores and instructions, and how to make examinations and tests with illustrations of several types that have found application. This work is unique in that no treatment is given of the so-called standardized tests.

The book is descriptive and argumentative but the author seems to have made a minimum use of the data which are offered as objective evidence of the issues of argument. This criticism seems especially applicable to the chapters on Merits and Limitations of Traditional and New-Type Examinations.

The illustrations of test items are extremely varied in nature and cover a wide range of subjects. But, here again objective data for evaluating the different types are lacking. Any one even fairly familiar with the testing movement is aware that the different forms of test items illustrated are not equally applicable and that some are hardly applicable at all.

The book, which has been prepared to meet the needs of teachers actually in service and as an introductory text in the field, may be expected to serve a useful purpose. Chemistry teachers who wish to become familiar with the discussions relating to the traditional and new-type tests as well as those looking for practical suggestions relating to the questions of how to make and how to use examinations will find much of interest in it. An appended

bibliography, selected and annotated, adds to the value of the work.

S. R. POWERS

TEACHERS' COLLEGE,
COLUMBIA UNIVERSITY

Laboratory Manual of High-School Chemistry. GEORGE HOWARD BRUCE, Horace Mann School for Boys, Teachers' College, Columbia University. World Book Company, Yonkers, New York, 1928. ix + 101 pp. Twenty illustrations of apparatus. 13 × 19 cm. $0.76.

In the preparation of this manual the author states that he has tried to keep in mind the point of view of the student. The experiments with the accompanying directions have been tried out in the classroom in mimeographed form, in proof, and in the first edition. Clearness of direction and ease of manipulation have been talked over with the students. The result of this painstaking effort is a series of experiments which are well within the understanding and manipulative skill of the average boy or girl. No difficult experiments have been included. So-called demonstration experiments have been omitted as more suitable for a teacher's handbook than for a laboratory manual.

The book is issued in both the bound form and the looseleaf form. The latter would, perhaps, be more readily adaptable for use with other texts than the author's High-School Chemistry which this manual was written to accompany. By making suitable change in the order of experiments, this manual might be used with any of the usual high-school texts in elementary chemistry.

The experiments offered are those usual to the beginner's course and include little that is new or markedly different. But the experiments are well thought out, the directions are clear and simple, and the questions are intended to direct the student's attention to essential points in the procedure or to stimulate thought on the matter in hand.

Some teachers would, doubtless, welcome more experiments on applied chemistry for use as optional material for the better students; such material often adds greatly to the interest of the course.

The twenty drawings of apparatus are excellent but it may be questioned if perspective drawings are as well adapted for elementary instruction as are the simpler line drawings. Where students are required to draw the apparatus used in an experiment, there are few who can do perspective well, while most pupils can do an acceptable line drawing.

The appendix contains the usual useful tables. The directions to students at the beginning of the book contain much useful and valuable advice as to laboratory procedure.

The book is well printed and bound. It will form a welcome addition to the list of laboratory manuals in which teachers of chemistry should be interested.

C. H. STONE

ENGLISH HIGH SCHOOL,
BOSTON, MASSACHUSETTS

The Development of the High-School Curriculum. Sixth Year Book, Dep't of Superintendence of N. E. A., The Nat. Educ. Assoc., 1201 Sixteenth St., N. W., Washington, D. C., 1928. 584 pp. with 53 tables. 15.5 × 23 cm. $2.00.

This volume is but one of a series of year books, which have emanated from the same source, upon curriculum construction. Former titles are: Elementary School Curriculum; Research in Constructing Elementary School Curriculum; The Nation at Work on the Public School Curriculum; and The Junior High-School Curriculum.

"The Development of the High-School Curriculum" is the work of twenty-four committees. The first twelve chapters deal with twelve outstanding issues which all local school systems must face before entering upon an extensive program of revision of secondary school curriculum. Among these chapter titles are: The Needs of American Youth; Objectives of Secondary Education; Curriculum Problems of

the Small High School; The Appropriateness of High-School Courses for Pupils Not Going to College; The Relationship between High School and College; Differentiation of Curriculum for Pupils of Different Levels of Ability; and The Junior College Curriculum with Special Reference to Orientation Courses.

Part II—Research in Secondary School Subjects—contains eleven chapters dealing in turn with outstanding investigations of curriculum material for: social studies; English; mathematics; science; modern and foreign languages; Latin; music; art; home economics; industrial subjects; and commercial subjects.

Part III consists of thirty pages devoted to Health and Physical Education in Junior and Senior High Schools.

The preface cautions the reader that "material presented . . . will have to be interpreted in the light of different conditions found in communities of varying size." Throughout the volume the reader should bear in mind the committee's definite policy that "none of the conclusions are presented with finality." Suggestions are given and each community is urged to solve its own problems as far as possible. To one who is at all conscious that our curriculum is still evolving this volume is both stimulating and helpful.

B. CLIFFORD HENDRICKS
UNIVERSITY OF NEBRASKA

Course of Study in Chemistry for the Senior High School. Published by the State Department of Public Instruction of New Jersey, 1928. 67 pp. 23 × 15.5 cm.

This report includes the following topics: Outline of Subject Matter, Terms, Chemical Equations, Experiments, A Few Suggested Demonstrations, Reference Materials, The Place of the History of Chemistry in a High-School Chemistry Course, A Brief Statement of the Main Theories Included in the Subject-Matter Outline.

The State Department of Public Instruction of New Jersey had two purposes for issuing this publication: (1) to set standards of work of secondary grade in this science, and (2) to outline a field of chemical science that will serve to make the community more intelligent in and appreciative of the benefits of this branch of knowledge.

The objectives which guided the committee in preparing this outline of the chemistry course are stated as follows: (1) To provide an opportunity, as a basis of good citizenship, for pupils to become acquainted with some of the applications of chemistry to home and community life, commerce, trades, and the professions. (2) To provide pupils with a broader appreciation and understanding of the world in which they live. (3) To provide opportunity for gaining chemical knowledge which will contribute to individual and community health. (4) To provide opportunity for training in the scientific method of thinking through the study of real chemical problems. (5) To provide pupils with a substantial foundation, so that the study of chemistry may be profitably continued if desired. (6) To provide an opportunity for thinking and imagining in scientific terms, to the end that the pupil may come to a decision as to whether chemistry offers for him a field for vocational activity. (7) To provide interests which may function in a more worthy use of leisure time.

This publication contains many valuable suggestions and useful material for high-school chemistry teachers.

M. W. G.

Chemical Treasures of the Forest. LOUIS E. WISE, Prof. of Forest Chemistry at The New York State College of Forestry, Syracuse, N. Y. Reprinted from *American Forests and Forest Life*, The Magazine of The American Forestry Assoc., Washington, D. C. 30 × 23 cm. 28 pp.

The seven papers contained in this booklet have the following titles: (1) Wonder Burners of Wood; (2) Knights of the Paper Trail; (3) Spinners of Wood; (4) Twilight of the Natural Dyes; (5)

Trees as Oil Producers; (6) Alcohol via the Wood Route; (7) Our Oldest Industry. Numerous excellent illustrations accompany these articles.

The material is recommended to both students and teachers.

M. W. G.

Teachers' Salaries in Certain Endowed and State Supported Colleges and Universities in the United States, with Special Reference to Colleges of Arts, Literature and Science, 1926-1927. TREVOR ARNETT. Occasional Papers, No. 8. General Education Board, New York City, 1928. 83 pp. 22.5 × 15 cm.

The Table of Contents is as follows: I. Previous Study of Teachers' Salaries; II. Procedure in Present Study; III. Comparative Salaries of Teachers; IV. Additional Earnings of Teachers; V. Provision for Increased Cost; VI. Conclusions; VII. Appendix.

The appendix, pages 33–83, includes (1) copies of questionnaires used in collection of data; (2) colleges of arts, literature, and science, and corresponding colleges and departments of universities—detailed tables, and (3) professional schools or departments.

M. W. G.

Abstracts of Scientific and Technical Publications from the Massachusetts Institute of Technology. Numbers 1 and 2. The Technology Press, Cambridge, Mass., 1928. 23 × 15 cm.

M. W. G.

Students' Kelvin Bridge. *Bulletin* No. **434.** Leeds & Northrup Co., Philadelphia, Pa., 1928. 26.5 × 20 cm. 8 pp.

In designing this instrument for use in the educational laboratory, special attention has been given to the following features: (1) the instrument is rugged and comparatively inexpensive; (2) the range is wide enough to demonstrate the applications of the method; (3) the accuracy is sufficiently high to command the user's respect; (4) the construction is simple, and affords a clear illustration of the fundamental principles of the method; (5) this instrument is a simplified model of the L. & N. Self-Contained Kelvin Bridge, which is widely used for laboratory and industrial purposes; (6) it is adapted to general use in the measurement of resistance from 0.1 ohm to 0.001 ohm when the accuracy required is of the order of 0.5 per cent.

The publication will be sent upon request.

M. W. G.

Automatic Control of Acid Baths. *Bulletin* No. **500.** Leeds & Northrup Co., Philadelphia, Pa., 1928. 8 pp. 26.5 × 20 cm. Free on request.

This apparatus is designed to maintain a uniform strength of acid in a bath used in the mercerizing process.

The publication will be sent upon request.

M. W. G.

Ten Years of Educational Research, 1918–1927. WALTER S. MONROE, Director, Bureau of Educational Research, College of Education, University of Illinois; Charles W. Odell, Asst. Director; M. E. Herriott, Associate; Max D. Englehart, Assistant; Mabel R. Hull, Assistant. Bulletin No. 42. Published by the University of Illinois, Urbana. 1928. 367 pp. $1.00.

This publication contains a complete survey of educational research carried out during the past ten years.

The table of contents is indicative of the material contained. **Part I:** Educational Research before 1918—the Pioneer Period; A General Survey of the Period 1918–27; Research in Educational Measurements; Curriculum Research. *Appendix A.* Tabular Summary of Activities of the Bureau of Educational Research at the University of Illinois 1918–27. *Appendix B.* List of Printed Publica-

tions of the Bureau of Educational Research at the University of Illinois, July 8, 1918, to June 30, 1928. **Part II:** Reports of Educational Research and Related Materials; Topical Index to the Reports of Educational Research and Related Materials; List of Doctors of Philosophy in Education by Institutions.

In the foreword by Dr. Monroe, we read: "This description of the activities of the Bureau of Educational Research during the first ten years of its existence is indicative of the general status of educational research during the period..... We have not clearly understood what educational research is or should be. The function of a department of educational research in a college of education has been even less clearly defined. It has been necessary for us to feel our way somewhat cautiously, and the changes in policy represent the recognition of needs for service. Under the present administration the research activities have varied widely. This policy was adopted intentionally, for it was believed that in this way we could appeal to a larger audience. Although we have carried on a number of studies in which objective methods were employed, a large portion of our resources have been devoted to research of the philosophical type. Studies of this character, together with those having to do with technics of research, are indicative of a significant phase of our present policy."

M. W. G.

Reprint and Circular Series of the National Research Council.

No. 83. Sixth Report of the Committee on Contact Catalysis. ROBERT E. BURK, in collaboration with other members of the committee. 1928. 47 pp. 17 × 24.5 cm. $0.50.

No. 84. I. The Fourth Census of Graduate Research Students in Chemistry, 1927. II. Support of Graduate Research in Chemistry in American Universities, 1927–28. CLARENCE J. WEST AND CALLIE HULL. 1928. 13 pp. 17 × 24.5 cm. $0.20.

M. W. G.

A CORRECTION

In the November number, page 1527, the address of Bobbs-Merrill Company was erroneously given as New York. The correct address is Indianapolis, Indiana.

Schools Should Do More than Teach. Schools should do more than train memories and teach facts, declared Dr. Rachel S. Yarros at the autumn meeting of the American Social Hygiene Association in Louisville, Ky. Our opportunities for recreation are limitless, so it is up to the schools and homes to train children to take advantage of such of these as are healthy and desirable. The schools must do their share in cultivating love of beauty in literature, music and other arts.

The home cannot provide one type of amusement for the parents and another for the children. In homes where parents find recreation and enjoyment in good books, music, and artistic drama, the children will grow up with a taste for the same thing.

The community, in turn, has a responsibility to fulfil in providing proper opportunities for recreation and this, according to Dr. Yarros, means more than playgrounds and municipal swimming pools.

"Every community large or small should provide or subsidize some form of music, popular lectures, little theaters, community entertainments, as well as ample facilities for physical exercises," he said.

This competition to low-grade movies, cabarets, and dance halls may seem a costly undertaking, but it will prove an economical way to prevent vice, crime, and unhappiness.—*Science Service*

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